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SUBUNGUAL NEUROMYO-ARTERIAL GLOMUS TUMOR OF THE TOE

EFFECT OF INCREASED PERIPHERAL TEMPERATURE

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CHICAGO

Neuromyo-arterial glomus structures are peculiar angioma-like collections of microscopic blood vessels normally found in the corium and subcutaneous tissue. They are considered peripheral arteriovenous anastomoses that function to maintain a constant capillary pressure and to control peripheral temperatures (Sucquet,[1] Hoyer,[2] Grosser,[3] Masson,[4] Popoff,[5] Grant and Bland [6]). Although such structures are distributed over the entire surface of the body, they are most numerous in the fingers and toes. When there is local hyperplasia a small, very painful and exquisitely tender bluish nodule results. Identification of the tumor as an arteriovenous anastomosis similar in histologic structure to the glomus coccygeum of Luschka was reported first by Masson,[4] of Strasbourg, in 1924. Since then reports of many cases have verified his conclusions (Stratmann,[7] Keasbey,[8] Adair,[9] Burman and Gold [10]).

From the Department of Surgery, Rush Medical College of the University of Chicago and the Presbyterian Hospital.

1. Sucquet, J. P.: D'une circulation dérivative dans les membres et dans la tête chez l'homme, Anatomie et physiologie, Paris, A. Delahaye, 1862.

2. Hoyer, H.: Ueber unmittelbare Einmündung kleinster Arterien in Gefässäste venösen Charakters, Arch. f. mikr. Anat. **13**:603-604, 1877.

3. Grosser, O.: Ueber arterio-venöse Anastomosen an den Extremitätenenden beim Menschen und den krallentragenden Säugethieren, Arch. f. mikr. Anat. **60**: 191-216, 1902.

4. Masson, P.: Le glomus neuromyo-artériel des régions tactiles et ses tumeurs, Lyon chir. **21**:257-280, 1924.

5. Popoff, Nicholas, W.: The Digital Vascular System, with Reference to the State of the Glomus in Inflammation, Arteriosclerotic Gangrene, Diabetic Gangrene, Thromboangiitis Obliterans and Supernumerary Digits in Man, Arch. Path. **18**:295-330 (Sept.) 1934.

6. Grant, R. T., and Bland, E. F.: Observations on Arteriovenous Anastomoses in Human Skin and in the Bird's Foot, with Special Reference to Reaction to Cold, Heart **15**:385-407 (July) 1931.

7. Stratmann, A.: Unusual Tumors in Nail Bed (Neuromyo-Arterial Glomus Tumor), Dermat. Ztschr. **67**:129-146 (Aug.) 1933.

(Footnotes continued on next page)

Conflicting clinical observations on the effect of peripheral circulatory changes in the glomus tumor have been reported. The characteristic bluish or bluish red color of the nodule during the painful crisis is due to the congestion in the blood spaces. Wood [11] noted in several of his 10 clinical cases that "during the painful crisis there was an increase in size of the tubercle and purplish or bluish discoloration of the skin at the same time." Likewise Mason and Weil [12] found that "compression of the tumor, or in other words emptying the blood vessels was immediately followed by the disappearance of the feeling of intense pain. Refilling of the vessels, indicated by the reappearance of the bluish color of the tumor, brought back again the painful sensation." Greig,[13] Lortat-Jacob and Brosse,[14] and Bonnet [15] also noted in some of their cases that cold relieved the painful crisis and warmth aggravated it. Conversely, Hall [16] described a typical clinical case in which the pain was "caused by and aggravated by cold, and relieved by warmth." Likewise, Masson,[4] Ianichewski and Lebel [17] and Raisman and Mayer [18] reported similar observations on the effect of heat and cold.

Paulian and his co-workers [19] described a case of subungual tumor of the finger in which they observed during the attacks of pain an increase in temperature of from 0.5 to 2 C. on the affected side as compared to the normal side. After local excision of the tumor this

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8. Keasbey, Louisa E.: Tumors of Glomus, Internat. J. Med. & Surg. **46**:431-432 (Sept.) 1933.

9. Adair, F. E.: Glomus Tumor: A Clinical Study with a Report of Ten Cases, Am. J. Surg. **25**:1-6 (July) 1934.

10. Burman, M. S., and Gold, A. M.: Glomus Tumor: Brief Clinical Study of Glomus Angio-Myo-Neurome Artériel of Barré and Masson, New York State J. Med. **35**:618-620 (June 15) 1935.

11. Wood, W.: On Painful Subcutaneous Tubercles, Edinburgh M. & S. J. **8**:283-291, 1812.

12. Mason, Michael, and Weil, Arthur: Tumor of a Subcutaneous Glomus, Surg., Gynec. & Obst. **58**:807-816 (May) 1934.

13. Greig, D. M.: Subcutaneous Glomus Tumors: Painful Subcutaneous Nodule, Edinburgh M. J. **35**:565-582 (Oct.) 1928.

14. Lortat-Jacob, L., and Brosse, T.: Tumeur sous-unguéale violacée, Bull. Soc. franç. de dermat. et syph. **35**:305-309 (April) 1928.

15. Bonnet, M. P.: Tumeur sous-unguéale douloureuse (glomus), Lyon chir. **24**:718-721, 1927.

16. Hall, M.: Case of Painful Subcutaneous Tubercle, Edinburgh M. & S. J. **11**:466, 1815.

17. Ianichewski, A., and Lebel, M.: Une variété de névralgie; la sympathalgie due à une tumeur glomique, Presse méd. **36**:116-118 (Jan. 28) 1928.

18. Raisman, Victor, and Mayer, Leo: Tumor of the Neuromyo-Arterial Glomus, Arch. Surg. **30**:911-929 (June) 1935.

19. Paulian, D.; Stefan-Popescu and Marinesco-Slatina, D.: Subungual Glomus Tumor Causing Hemihyperthermia: Complete Cure After Surgical Removal, Ann. d'anat. path. **10**:271-276 (March) 1933.

difference in temperature disappeared. The reverse was noted by Thomas,[20] who found a lowering of the local temperature of the part affected. However, the location of the tumor deep in the muscles of the thigh places this case in a different category than the other cases of superficial tumors.

The frequent mention of the clinical effect of heat and cold, or in other words vasomotor circulatory changes, in association with these tumors, although divergent, indicates a relationship of the circulation to the paroxysms of pain. This is explained by the histologic structure richly supplied with nerve fibers. In one of Masson's cases periarterial sympathectomy was performed for relief of the excruciating, radiating

Fig. 1.—Glomus tumor protruding beneath the nail of the right first toe.

pains before a subungual tumor was discovered. Excision of the tumor was followed by complete relief.

In a case of senile arteriosclerotic circulatory disease herewith reported normal thermocouple temperature readings followed treatments with alternating positive and negative pressure. After complete relief was obtained from the subjective symptoms, an excruciatingly painful and tender bluish pea-sized tumor was discovered protruding from beneath the right first toe-nail (fig. 1). This nodule had not been noticed previously. Histologic examination of the tumor confirmed the diagnosis of a subungual glomus tumor. No similar case report has been found in the literature.

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20. Thomas, André: Tumeurs comparables à des tumeurs glomiques développées dans les muscles de la cuisse à la suite d'un traumatisme, Ann. d'anat. path. **10**:657-668 (June) 1933.

REPORT OF A CASE

E. M., aged 69, of Irish birth, a machinist, was examined on Feb. 5, 1935. For more than one year he had constant pain in the calf of the right leg (rest pains). The pain became especially severe after he walked two or three blocks, and he had to rest a few minutes before continuing (intermittent claudication). Pulsation was absent in both the dorsalis pedis and the posterior tibial artery but was present in the popliteal artery. A roentgenogram revealed marked sclerosis of the arteries of the right leg and foot. The foot was definitely cold to touch, and the patient stated that the coldness had troubled him for years. There was no ulceration or dependent discoloration. The left foot and leg had given no trouble, and all arterial pulsations were moderately palpable.

On March 7, after sixteen hours of treatment with positive and negative pressure, the patient reported complete relief from intermittent claudication and rest pains, which enabled him to return to physical labor. On March 18 thermocouple temperature readings after stabilization at 23 C. revealed almost normal circulation in the right foot. The patient's condition continued to be satisfactory until April 30, when he reported that he felt fine except for the excruciating pains in the right first toe. On examination a firm very tender, bluish nodule the size of a pea was found protruding from beneath the tip of the toe-nail (fig. 1). This was

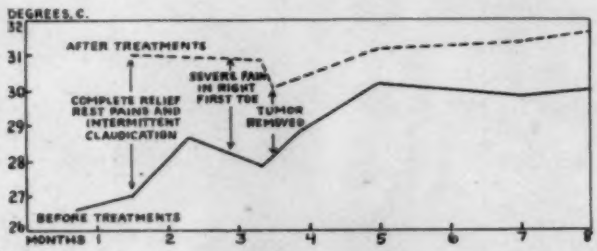

Fig. 2.—Chart showing thermocouple temperature readings in centigrade of the right first toe before (solid line) and after (interrupted line) one hour treatments with alternating positive and negative pressure over a period of eight months. Note the drop in temperature as the excruciating pains develop in the right first toe. After excision of the tumor the rapid improvement in temperature readings was maintained.

so tender that palpation was almost impossible. A roentgenogram of the toe showed no osseous changes or exostoses. The treatments with positive and negative pressure aggravated the excruciating pains. Because a roentgenogram failed to show a subungual exostosis, a diagnosis of subungual glomus tumor was made. On May 21, the tumor was removed. The wound healed rapidly, and the patient was free from all symptoms. No further treatments for the peripheral circulatory disease were given until August 22 when the patient complained of the return of the intermittent claudication. Prompt relief was obtained by treatments with alternating positive and negative pressure. By September 12, he was again able to walk rapidly for more than a mile (1.6 Km.) without distress or resting. He also stated that his legs perspired, an occurrence which he had not noticed for years. Without further treatments he has had occasional periodic return of intermittent claudication. However, the right first toe has caused no further trouble (November 20), and he has no rest pains. The stabilized peripheral tem-

perature has remained within normal limits, and the patient recently walked 7 miles (11.2 Km.) without distress or resting.

Comment.—The coldness of the extremity to palpation, the intermittent claudication and the rest pains indicated deficiency in the peripheral circulation. A

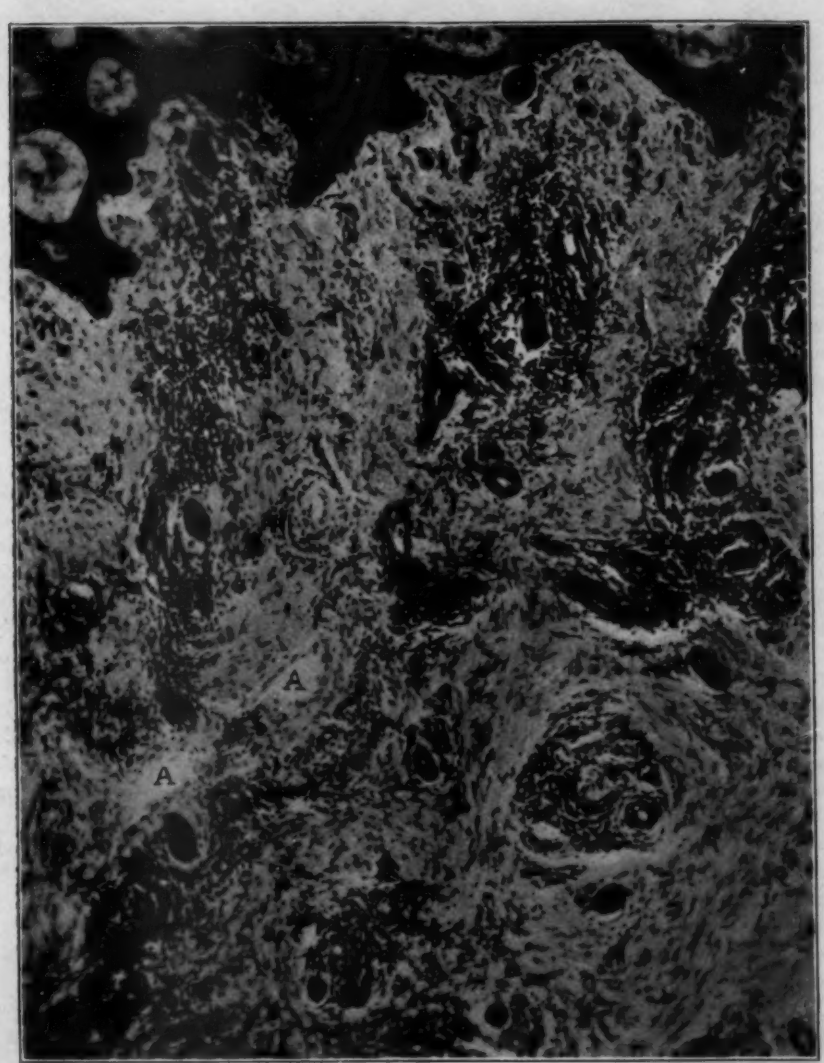

Fig. 3.—Low power photomicrograph of a section of a glomus tumor. The dark cellular structures are hyperplastic glomus units, with intervening loose collagenous connective tissue. *A* indicates the empty venous spaces.

roentgenogram of the right leg and foot revealed marked sclerosis of the arteries. As the circulation was improved by treatments with positive and negative pressure, the foregoing symptoms and clinical findings disappeared. With the return of

normal peripheral temperature, the circulation was sufficient to engorge the capillaries in the glomus tumor of the right first toe, with resulting excruciating pain. A drop in the peripheral temperature was then noticed (fig. 2). This was probably due to an arteriospasm caused by the painful tumor. Excision of the tumor brought relief from pain and almost normal circulation. An improvement was found not only in the temperature readings but to a slight degree in the oscillometric readings.

Pathologic Picture.—Grossly, the small, firm, elongated, fleshy tumor measured about 1 by 0.5 cm. and 0.6 cm. in depth. The epidermal covering was firm and tough, while the underlying tissue was soft and spongy. There was no capsule or line of separation between the nodule and the normal tissue.

Sections were prepared and stained with Mallory's eosin and methylene blue, hematoxylin and eosin, Mallory's phosphotungstic acid and hematoxylin and by the methods of Van Gieson and Davenport and Foote's modification of Bielschowsky's method.

Microscopic examination under low power magnification (fig. 3) revealed a thickened layer of normal epidermis. In the corium irregularly distributed clusters of dense basophilic cellular structures extended throughout the section. These areas were separated by loose collagenous connective tissue, within which thin-walled empty endothelium-lined spaces appeared. Within the dense basophilic cluster of cells there was a centrally located thick-walled vessel with a small lumen.

Under high power magnification characteristic glomus structures were seen (fig. 4). Each cluster of basophilic cells contained from four to six centrally located vessels resembling coil glands which were lined with several layers of epithelioid or glomus cells. Some of these cells with oval or round cell nuclei contained well defined nucleoli. The cytoplasm was clear and faintly staining. A few spindle-shaped forms were present. No mitotic figures were seen. The lumens of these vessels were slitty, irregularly shaped and usually eccentrically located. Around the circular groups of glomus cells was a well defined layer of flat muscle cells. These units were described as the Sucquet-Hoyer canals [21] of the S-shaped arteriovenous anastomoses. Collecting veins were seen as slitlike spaces around these structures. They were easily mistaken for artefacts but could be clearly demonstrated to be lined with a thin layer of flat endothelium. Vessels of a third type seen in this tumor were the preglomic arterioles with large lumens. These were the tortuous vessels with a single layer of endothelium of flat elongated cells with oval nuclei. The elastic lamina was retained in these vessels, and they were found therefore filled with red blood corpuscles.

A satisfactory preparation by the silver staining method of Davenport was not obtained. However, with Foote's modification of the Bielschowsky method numerous argentophilic fibers were seen extending between the epithelioid or the glomus cells toward the lumen of the Sucquet-Hoyer canals.

COMMENT

A neuromyo-arterial glomus tumor is a rare form of blood vessel neoplasm. Geschickter and Keasbey,[22] in reporting on a series of 570

21. Picard, Hugo: Ueber seltene Tumorem am Nagelbett, Zentralbl. f. Chir. **58**:2133-2135, 1931. Masson.[4]

22. Geschickter, Charles F., and Keasbey, Louisa E.: Tumors of Blood Vessels, Am. J. Cancer **23**:568-591 (March) 1935.

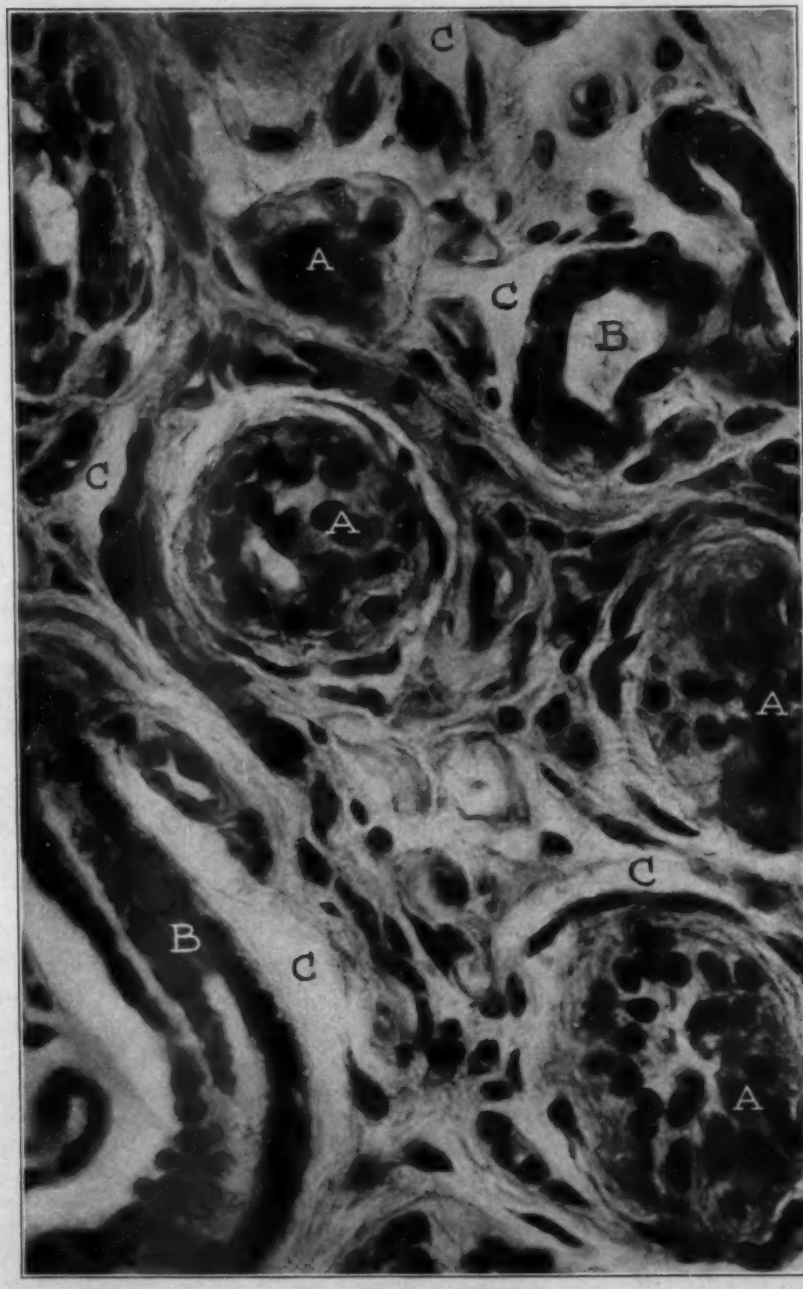

Fig. 4.—High power photomicrograph of a section of a glomus tumor showing four Sucquet-Hoyer canals (*A*) with small empty lumen (note the epithelioid or glomus cells of several layers thickness); preglomic arterioles filled with red blood cells (*B*) and flat endothelial-lined collecting veins (*C*).

clinical and pathologic tumors of blood vessels from the Johns Hopkins Hospital, included 10 glomus tumors; 6 of the tumors were located on the hand or fingers, 2 on the leg or thigh, 2 on the forearm and none on the toes. More recently, Lewis and Geschickter [23] collected from the laboratory of surgical pathology of the Johns Hopkins Hospital reports of 17 cases, in 4 of which the tumor was subungual. As the terminology suggested by Masson indicates, nervous and muscular structures and blood vessels predominate in the tumor. Nerve fibers are abundantly distributed within and outside the Sucquet-Hoyer canals.[24] The epithelioid or glomus cells are generally considered to be transversely sectioned muscle cells of the thick muscular wall of the anastomoses. They appear not unlike the ducts of sweat glands.[13] The presence of argentophilic fibers coursing between the epithelioid muscle cells are characteristic of the anastomotic canals.

Although normal neuromyo-arterial glomus structures are distributed over the surface of the body, the hyperplastic growths are found less frequently in locations where the normal units are the most numerous. Grant and Bland [6] studied normal adult fingers and found per square centimeter of skin surface on an average of 501 glomus units in the nail bed and 236 in the finger tips, the number decreasing rapidly in the central location. Greig,[13] of Edinburgh, Scotland, the first to describe these tumors in the English literature, recorded 23 cases of glomus tumor, in only 1 of which the tumor was digital and that occurred on a finger. In 65 cases reports of which were collected by Bailey,[25] 21 of the tumors were subungual, only 1 of these being on the lower extremity. In the 62 cases reported by Stout,[26] 26 of 45 tumors of the upper extremity were subungual, while of 16 tumors of the lower extremities only 1 was subungual. In all 3 cases originally studied and identified by Masson, the tumor was in the nail bed of a finger.

Clinically, a glomus tumor is characterized by a small bluish subcutaneous nodule of unusual tenderness and paroxysms of localized or radiating pain, often of extreme severity. In Geschickter's series of cases the age varied from 18 to 82 years. However, Ireland,[27] at the Childrens Memorial Hospital in Chicago, verified by histologic study a glomus tumor excised from a child 9 years of age. The duration of

23. Lewis, Dean, and Geschickter, Charles F.: Glomus Tumors, J. A. M. A. **105**:775-778 (Sept. 7) 1935.

24. Lewis, T., and Pickering, G. W.: Vasodilatation in the Limbs in Response to Warming the Body with Evidence for Sympathetic Vasodilator Nerves in Man, Heart **16**:33-51 (Oct.) 1931.

25. Bailey, Orville T.: The Cutaneous Glomus and Its Tumors—Glomangiomas, Am. J. Path. **11**:915-936 (Nov.) 1935.

26. Stout, Arthur Purdy: Tumors of the Neuromyo-Arterial Glomus, Am. J. Cancer **24**:255-272 (June) 1935.

27. Ireland, Jay: Personal communication to the author.

symptoms may vary from two weeks, as in the case reported here, to thirty-seven years, as in Mason and Weil's case. As to sex distribution, Stout found that the great majority of the subungual tumors and tumors of the finger occur in females, while the tumors occurring elsewhere on the extremities are more frequent in males. Other authors report about an equal distribution.

Trauma is the only etiologic factor of significance. In about 50 per cent of the cases a history of injury is given. Many tumors, however, were without apparent cause. The locations where these nodules are commonly found lend themselves most easily to injury.

The benign character of a glomus tumor is substantiated by the fact that no recurrences have been reported after local excision. The tumor is not known to metastasize and is not invasive in its growth, although definitely demonstrated encapsulation is not always present. Prior to Masson's investigation such tumors were diagnosed as perithelioma, painful subcutaneous tumor,[18] neurinoma and angiosarcoma (Kolaczek,[28] Kraske [29] and Carstensen [30]). Occasionally, when the last diagnosis was made, amputation of the digit was recommended and performed. A more radical surgical procedure than local excision is unnecessary. Complete and permanent relief from symptoms and rapid healing of the wound follow local excision.

In most of the cases of glomus tumor heretofore recorded the condition was not recognized clinically. The numerous recent reports in medical literature will no doubt stimulate interest in the significance and importance of both the normal and the pathologic terminal arteriovenous anastomoses. This has already been noted by the thorough investigation of Popoff,[5] who has identified changes in the terminal structures as characteristic of diabetes, senility and thrombo-angiitis obliterans. No further report has as yet substantiated his belief that senile and diabetic peripheral arterial diseases are not pathologically identical.

The normal glomus structures are unequally distributed over the surface of the body, being most numerous, however, on the fingers and toes. It is peculiar that hyperplasia with resulting tumor formation is found most frequently where the normal units are least numerous. Of the 65 collected cases reported by Bailey, in only 1 was the tumor subungual and located on the toe.

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28. Kolaczek, J.: Ueber das Angiosarkom, Deutsche Ztschr. f. Chir. **9**:165-227 (Jan.) 1878.

29. Kraske, P.: Ueber subunguale Geschwülste, München. med. Wchnschr. **34**:889-891, 1887.

30. Carstensen, I.: Ueber subunguale Tumorem, Arch. f. klin. Chir. **144**:409-431, 1927.

The fact that in the case herewith recorded the nodule was not discovered until the peripheral circulation was increased had no etiologic significance. In more than 195 cases in which I have employed the same method of therapy no other tumor was discovered. Neither did Allen,[31] of the Mayo Clinic, in approximately 250 cases, nor de Takáts [32] in 100 cases, find a case of neuromyo-arterial glomus tumor. In Herrmann's [33] 600 cases of peripheral circulatory disease he found no glomus tumor. Scott [34] used positive and negative pressure therapy in 100 cases but in 2 cases of glomus tumor of the hand in which treatment was not directed to the peripheral arterial disease he excised the tumor. Landis [35] administered treatment in 225 cases without encountering a glomus tumor. These tumors remain small and are not known to become much larger than was found in my case. It is therefore reasonable to persume that the treatment or the resulting increase in the peripheral circulation was not responsible for the hyperplasia of the glomus structures. It is more likely that the adequacy of the circulation determines the clinical characteristics of a glomus tumor. Without sufficient blood in the anastomotic units, engorgement of the vessels does not take place, so that the presence of the tumor is overlooked. With overfilling of the vessels, bluish discoloration of the tumor occurs. The nerve endings, either within the anastomosis [25] or in the surrounding tissues,[36] are thereby stimulated with resulting exquisite pain and tenderness.

Histologic investigation of the neuromyo-arterial glomus has shown that the arteriovenous anastomosis is a direct offshoot from the cutaneous papillary vessels.[37] The structure is likened to a shunting process in which the amount of blood exposed to the cutaneous surface is controlled. Dilatation of the thick muscular-walled arteries (Sucquet-Hoyer canal, fig. 4*A*) permits a varying amount of blood to be shunted directly back to the venous system. A similar anatomic arrangement of direct artery and vein connection in the wing of a bat was described by Paget.[38]

Under pathologic conditions with tumor formation the congestion of the blood spaces produces a bluish swelling. The resulting pressure on the surrounding nerves gives rise to paroxysms of pain. Conversely,

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31. Allen, E. V.: Personal communication to the author.
32. de Takáts, G.: Personal communication to the author.
33. Herrmann, Louis G.: Personal communication to the author.
34. Scott, W. J. Merle: Personal communication to the author.
35. Landis, Eugene: Personal communication to the author.
36. Hopf, Max: Neuromyo-Arterial Glomus Tumor (Masson), Frankfurt. Ztschr. f. Path. **40**:387-399, 1930. Mason and Weil.[12] Masson.[4]
37. Grant and Bland.[6] Masson.[4] Picard.[21]
38. Paget, James, quoted by Todd, Robert B.: Cyclopedia of Anatomy and Physiology, London, Longman and others, 1852, vol. 4, p. 1386.

contraction of the muscular walls of the vessels as a result of exposure to cold may compress the nerve fibers between the epithelioid cells of the vessel walls and produce pain. In this way the divergent observations of the effect of heat and cold on the painful paroxysms may be due to different physiologic processes.

Present knowledge of the cutaneous glomus is primarily the result of histologic investigation (Sucquet,[1] Hoyer,[2] Masson,[4] Popoff,[5] Grosser[3]). However, T. Lewis and his co-workers investigated these microscopic structures in order to explain their observation on the regulatory mechanism of the peripheral circulation. Lewis and Pickering,[24] and Grant and Bland [6] expressed the belief that these anastomoses must be taken into account in dealing with peripheral circulation. In new-born and in elderly persons the cutaneous temperature regulation is poor. In these same groups the normal glomus units are poorly developed or atrophic and less numerous than in adults. Likewise, Grosser reported that reptiles, cold-blooded amphibians, are not supplied with them at all. This would be expected if the neuromyo-arterial glomus is definitely established as the regulatory mechanism of the peripheral circulation.

CONCLUSIONS

A subungual neuromyo-arterial glomus tumor of the toe occurring in a patient suffering from senile arteriosclerotic peripheral circulatory disease is herewith reported. Histologic examination confirmed the diagnosis of a glomus tumor.

The tumor was not discovered until the development of an excruciating painful crisis and exquisite tenderness of the toe. These symptoms followed improved circulation produced by treatments with alternating positive and negative pressure.

In more than 1,400 patients with peripheral circulatory disease treated with alternating positive and negative pressure no other glomus tumor was found.

In no other reported case of glomus tumor has a similar study of peripheral temperatures been made.

HEMANGIOMA OF A TENDON OR TENDON SHEATH

REPORT OF A CASE WITH A STUDY OF TWENTY-FOUR CASES FROM THE LITERATURE

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CHICAGO

In 1930 Burman and Milgram [1] could find records of only sixteen cases of hemangioma of a tendon or of a tendon sheath, including six cases of their own and ten previously reported in the literature. In the present article a case is presented, and reports of eight more are collected from the literature, making the total of reported cases twenty-four. One of Burman and Milgram's cases is not included.

REPORT OF CASES

CASE 1 (Richet,[2] 1860).—A child aged 10 years complained of swelling of the lower two thirds of the right forearm of twenty months' duration. No murmur was heard on auscultation, but pressure could produce filling and emptying. A diagnosis of a venous erectile tumor was made, and treatment by injections of ferric chloride gave perfect results.

CASE 2 (Delagénière,[3] 1894).—A seamstress aged 41 had noted seventeen years before operation that she had pain in the right wrist and swelling 5 cm. above the wrist. Two or three years later the tumor began to grow. At operation a cavernous hemangioma involving the extensor pollicis tendon was found.

CASE 3 (Schwartz,[4] 1908).—A man aged 41 was injured sixteen months before operation with resultant persistent swelling over the right achilles tendon and interference with the movement of the right ankle. At operation an essentially capillary, partially cavernous hemangioma was found.

CASE 4 (Partsch,[5] 1914).—A man aged 26, a land inspector, had swelling of the left forearm of three years' duration. Operation was performed. Because of recurrence one year later, there was a second operation.

CASE 5 (Weil,[6] 1914).—A woman aged 23, a music teacher, had a painful swelling of the lower third of the flexor surface of the left forearm for five years

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1. Burman, M. S., and Milgram, J. E.: Hemangioma of Tendon and Tendon Sheaths, Surg., Gynec. & Obst. **50**:397-406, 1930.

2. Richet, cited by Weil.[6]

3. Delagénière, cited by Weil.[6]

4. Schwartz: Ein Fall von fibromatöser Verdickung der Achillessehne, München. med. Wchnschr. **55**:1235-1236 (June 9) 1908.

5. Partsch, cited by Weil.[6]

6. Weil, S.: Ueber peritendinöse Angiome, Beitr. z. klin. Chir. **88**:56-68, 1914.

following an injury. Roentgen examination showed well defined opaque bodies, and at operation a cavernous hemangioma was found.

CASE 6 (Weil,[6] 1914).—A maidservant aged 18 had nodules on the fingers of the left hand and on the left forearm since the first month of life. Roentgen examination showed a few definite phleboliths. At operation a cavernous hemangioma was found.

CASE 7 (Chauvin and Roux,[7] 1920).—A young woman complained of swelling on the dorsum of the right foot following trauma, with the formation of a hematoma four years before operation. At operation a tumor attached to the extensor tendon of the fourth toe was found. Histologic examination revealed endothelial, cavernous hemangiomatous and fibrochondromatous tissue.

CASE 8 (Janik,[8] 1927).—A married woman aged 40 had a painless swelling attaining the size of a fist on the right forearm of five years' duration. At operation endothelial, cavernous and fibrous tissue was found attached to the sheath of the flexor digitorum sublimis on the volar aspect of the forearm, and a diagnosis of hemangiofibroma was made.

CASE 9 (Burman and Milgram,[1] 1930).—A man, whose age was not stated, had pain in the left knee of six years' duration. Operation was performed. There was a recurrence of pain three and one-half years later, and another operation was performed. A cavernous hemangioma involving the left quadriceps tendon coincident with a port wine nevus of the base of the neck was found.

CASE 10 (Burman and Milgram,[1] 1930).—A girl aged 10 years had a growth on the palmar aspect of the distal portion of the left little finger and on the left wrist, which had been present since birth and a tumor on the left forearm which had been present for one year. Both were painless. When the finger was pricked, blood spurted more than from other fingers. The size changed with elevation and depression of the arm. Boiling water was injected into the tumor of the finger, and the tumor of the wrist was removed surgically, a cavernous hemangioma being found. An operation for recurrence of the tumor in the wrist and partial resection of the tumor in the forearm were performed one year later. In spite of roentgen therapy, there was subsidence of the condition but not complete cure.

CASE 11 (Burman and Milgram,[1] 1930).—A Negro girl aged 7 years had a growth on the outer side of the left leg of four years' duration. Operative removal of a cavernous hemangioma of the peroneus cuboideus tendon was performed, and there was no recurrence after seven months.

CASE 12 (Burman and Milgram,[1] 1930).—A woman aged 22 had a nodule in the left popliteal region of seventeen months' duration. Operative removal of a capillary hemangioma from the left semitendinous tendon was performed, and there was no recurrence after six months.

CASE 13 (Burman and Milgram,[1] 1930).—A man aged 57 had a painful swelling on the volar surface of the right wrist for two years. Operative removal of a capillary hemangioma attached to the flexor tendons was performed.

CASE 14 (Burman and Milgram,[1] 1930).—A woman aged 26 had a swelling on the leg for several years. Operative removal of a cavernous hemangioma of the plantaris tendon was performed. The side was not stated.

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7. Chauvin and Roux: Fibro-chondroma de la gaîne tendineuse de l'extenseur du quatrième orteil, Bull. et mém. Soc. anat. de Paris **90**:75-77 (Feb.) 1920.

8. Janik, Alfred: Tumors of Tendon Sheaths, Ann. Surg. **85**:897-911 (June) 1927.

CASE 15 (Della Mano,[9] 1932).—A woman aged 51 had multiple hemangiomas of the tendons of the left hand of seventeen years' duration. Roentgen examination revealed calcified granules in several of the tumors in the metacarpal and proximal phalangeal regions. At operation a mixed cavernous and capillary hemangioma was found.

CASE 16 (Principalli,[10] 1932).—A housewife aged 14 had a swelling of the left foot for four years. At operation a partly cavernous hemangioma of the tendon of the peroneal muscle of the left foot was found.

CASE 17 (Grandclaude, Razemon and Bizard,[11] 1933).—A man aged 31 had noted a tumor as large as a "nut" near the anatomic snuff box several months before. Later there was sudden rupture of the tendon while using the hand. The side was not stated. Operative excision and tendon graft were performed, and a cavernous hemangioma attached to the long extensor of the thumb was found.

CASE 18 Botto Micca,[12] 1934).—A man aged 28, a bricklayer, had swelling of the dorsum of the right hand. Roentgen examination showed calcareous granules. At operation a cavernous hemangioma attached to the extensor tendons was found.

CASE 19 (Morton,[13] 1934).—A man aged 21 had a previous operation for removal of a tumor the size of a walnut from the anterolateral aspect of the right wrist at the age of 4 years. There were recurrence at the age of 11, a painful period at the age of 13 and a return of pain several months before admission, but no change in the size of the swelling. Roentgen examination did not reveal any phleboliths or involvement of the bone. Operation revealed a tumor attached to two extensor tendons of the thumb. A cavernous fibrohemangioma was found on microscopic examination, and there was no recurrence after eleven months.

CASE 20 (Gottstein[14]).—The patient showed no recurrence ten years after operation.

CASE 21 (Furlkröges[15]).

CASE 22 (Koropovski[16]).

CASE 23 (Pitzorno[17]).

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9. della Mano, N.: Angioma cavernoso delle guaine tendinee, Policlinico (sez. chir.) **39**:593-612 (Oct.) 1932.

10. Principalli, Silvio: Contributo alla conoscenza dei tumori vasculari delle guaine tendinee, Chir. d. org. di movimento **17**:128-132 (June) 1932.

11. Grandclaude, C.; Razemon, P., and Bizard, G.: Angio-lipoma arborescent de la gaine tendineuse du long extenseur du pouce ayant déterminé la rupture du tendon, Ann. d'anat. path. **10**:444-446 (April) 1933.

12. Botto Micca, Augusto: Contributo allo studio degli angiomi cavernosi dei tendini, Riv. san. siciliana **22**:568-577 (April 15) 1934.

13. Morton, J. J.: Tumors of the Tendon Sheaths: Their Close Biological Relationship to Tumors of the Joints and Bursae, Surg., Gynec. & Obst. **59**:441-452 (Sept.) 1934.

14. Gottstein, cited by Weil.[6]

15. Furlkröges, cited by Botto Micca.[12]

16. Koropovski, cited by Botto Micca.[12]

17. Pitzorno, cited by Tison and Hubert.[20]

In reviewing these cases several borderline examples have not been included. Van Neck [18] reported the case of a woman aged 56 with symptoms of pain in the left knee of less than one year's duration. Roentgen examination revealed an area of rarefaction about 1 cm. in diameter in the patella. At operation a hemangioma was found in this cavity. Despite its removal, the area of rarefaction persisted, as shown in subsequent roentgenograms. Although the patella is a sesamoid bone arising in a tendon, this case is not included in those of tumor arising in a tendon proper. Bouquet [19] reported the case of a man, whose age was not stated, an electrician, with a swelling of the left forearm of two years' duration. Roentgen examination revealed definite small concentric opaqe rings with relatively less opaque centers. Operation revealed that a cavernous hemangioma arose from the deep muscles and especially the interosseous membrane. Although this tumor arose primarily from the interosseous membrane, it is not considered to be of strictly tendinous origin.

Five cases of lymphangioma arising from a tendon or a tendon sheath have been reported in the literature, but they are not included in the group of hemangiomas proper. Principalli [10] reported the case of a woman aged 51, a housemaid, with a swelling of the volar surface of the base of the ring finger of at least seven weeks' duration. Operation revealed a lymphangio-endothelioma. Von Albertini [20] reported a case of lymphangioma of a tendon. Huguenin and Oberling [21] reported two such cases. The first is that of an infant aged 3 years with a lymphangioma in the infrapatellar portion of the quadriceps tendon, which had been present since birth. The sex and the side of the body on which the swelling was located were not stated. Their second case was that of a man aged 47, a Lithuanian, with three tumors. One was on the palmar surface of the right ring finger and was considered too small to operate on. The other two were on the left hand, and on removal they were found to be lymphangiomas. As in the case of vascular tumors of other origin than from a tendon or a tendon sheath, the exact differentiation between hemangioma and lymphangioma is indistinct and somewhat arbitrary. In this regard the authors stated: "Les vaisseaux sanguins au voisinage de la tumeur sont très developpés, et la présence de sang dans certaines cavités de la tumeur fait penser que des vaisseaux sanguins y sont fait irruption."

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18. Van Neck, M.: Un cas d'angiome de la rotule, Scalpel **86**:915-917 (June 17) 1933.

19. Bouquet, H., and DeBeayeu, A. Jambert: Un cas d'hémangioma primitif d'origine musculo-aponévrotique, Arch. d'électric méd. **41**:277-280 (July) 1933.

20. Von Albertini, cited by Grandclaude, Razemon and Bizard.[17]

21. Huguenin, R., and Oberling, C.: Lymphangiomes des tendons, Bull. Assoc. franç. p. l'étude du cancer **20**:144-150 (Feb. 23)1931.

(The blood vessels in the region of the tumor are greatly enlarged, and the presence of blood in certain cavities of the tumor leads one to conclude that extravasation has taken place.) Faldini [22] reported a case of lymphangio-endothelioma of the tendon sheaths of the region of the ankle with metastatic tendencies. (This case is included in the total of sixteen instances of hemangioma collected by Burman and Milgram; it is not included in the present article.)

CASE 24 (Author's Case).—Miss R. K., aged 20, a housemaid of Swedish descent, entered the University of Chicago Clinics on Jan. 10, 1935, complaining of a painful swelling of the palmar surface of the left forearm of five months' duration. The onset of the condition was gradual, with no history of an antecedent injury. The growth of the swelling was steady, and during the past few months it was especially painful after the patient did her usual household duties. She believed that the left arm was becoming weaker than the right, and she "favored" it in her work. As an incidental complaint, she had been troubled with some nervousness and hyperhidrosis for several months.

Physical examination revealed a swelling about 5 cm. long and 3 cm. wide just above the wrist on the palmar aspect of the left forearm. This swelling was somewhat soft and semifluctuant and was not attached to the skin. It contained several hard nodules in its substance. It was somewhat movable, especially transversely, and did not seem to be attached to bone. The overlying skin was not discolored, but some of the neighboring veins were slightly enlarged. There was no thrill present, and auscultation was not performed. The length of the two forearms was equal; the circumference of the right was 23 cm., and that of the left, 21.5 cm. An incidental finding was the arterial blood pressure of 164 systolic and 98 diastolic, which was equal in the two arms. The urine, the white blood count and the hemoglobin content were normal. The Wassermann and Kahn reactions were negative. The basal metabolic rate was plus 16 on one examination and plus 7 on another.

Roentgen examination revealed no abnormality of the chest or neck. There was a soft tissue swelling of the ulnar and the flexor aspect of the left forearm just above the head of the ulna, in which there were areas of calcification, several as much as 2 mm. in diameter. A preoperative diagnosis of hemangioma of unknown origin was made.

Operation was performed on January 14 by Dr. H. Perry Jenkins. After the application of an elastic constrictor, which compressed blood out of the forearm, the tumor appeared to be definitely smaller. A longitudinal incision was made, and a bluish red tumor lying along the tendon of the flexor carpi ulnaris muscle was exposed. A superficial branch of the ulnar nerve and several blood vessels entered and coursed through the tumor and had to be ligated and removed. The constrictor was removed, bleeders were controlled and the wound was closed.

The patient was free from pain, and the wound healed promptly. A month after operation a small nodule was noted beneath the scar. This grew slowly and had become about 2 cm. in diameter and was elevated 1 cm. when it was excised, a year after the previous operation. At that time it was soft and not very compressible and did not change in size on elevation or depression of the arm or after shutting off the circulation by application of a blood pressure cuff. At the second operation (performed by me) the tumor was again adjacent to the

22. Faldini, cited by Burman and Milgram.[1]

flexor tendons of the wrist but not definitely originating from any of them. The postoperative course was uneventful this time, and five months later there was no sign of recurrence.

Pathologic examination after the first operation showed the collapsed specimen to consist of a piece of meaty tissue measuring 3 by 2 by 2 cm. It was covered by a fibrous capsule under which small dark red lobules were seen. On palpation hard red nodules were felt within. Histologic examination revealed a fragment of dense fibrous tissue in which was found several areas containing endothelium-lined cavernous spaces containing red blood cells. In places there was slight hyperplasia of these endothelial cells. In the section which was prepared from the collapsed specimen, about one third of the tissue seemed to be composed of cavernous spaces and two thirds of fibrous tissue. In few regions was there

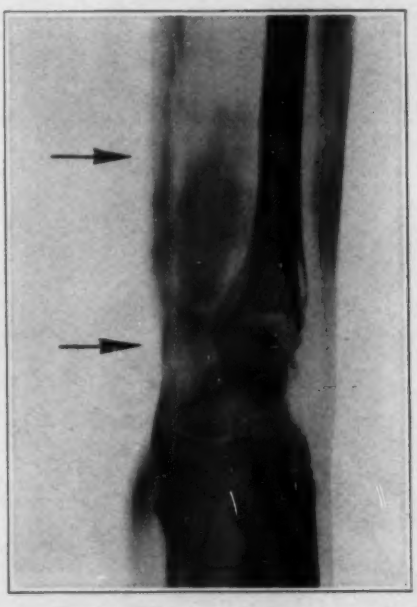

Fig. 1 (case 24).—Lateral roentgenographic view of the left wrist. The outline of the tumor is faintly seen on the volar surface, its upper and lower limits being marked by the arrows. In the substance of the tumor are seen several areas of calcification.

tissue resembling a capillary hemangioma. In one section two rounded masses of living bone were seen lying next to a group of cavernous spaces. Figure 1 shows the cavernous spaces and adjacent living bone. The specimen obtained at the second operation was similar except that it contained no bone.

Two additional cases observed at the University of Chicago Clinics are not included in the foregoing series since the exact relation of the condition to a tendon or a tendon sheath was not conclusively proved. In the first of these additional cases, B. F., a high school student aged 17, complained of inability completely to flex or extend the right

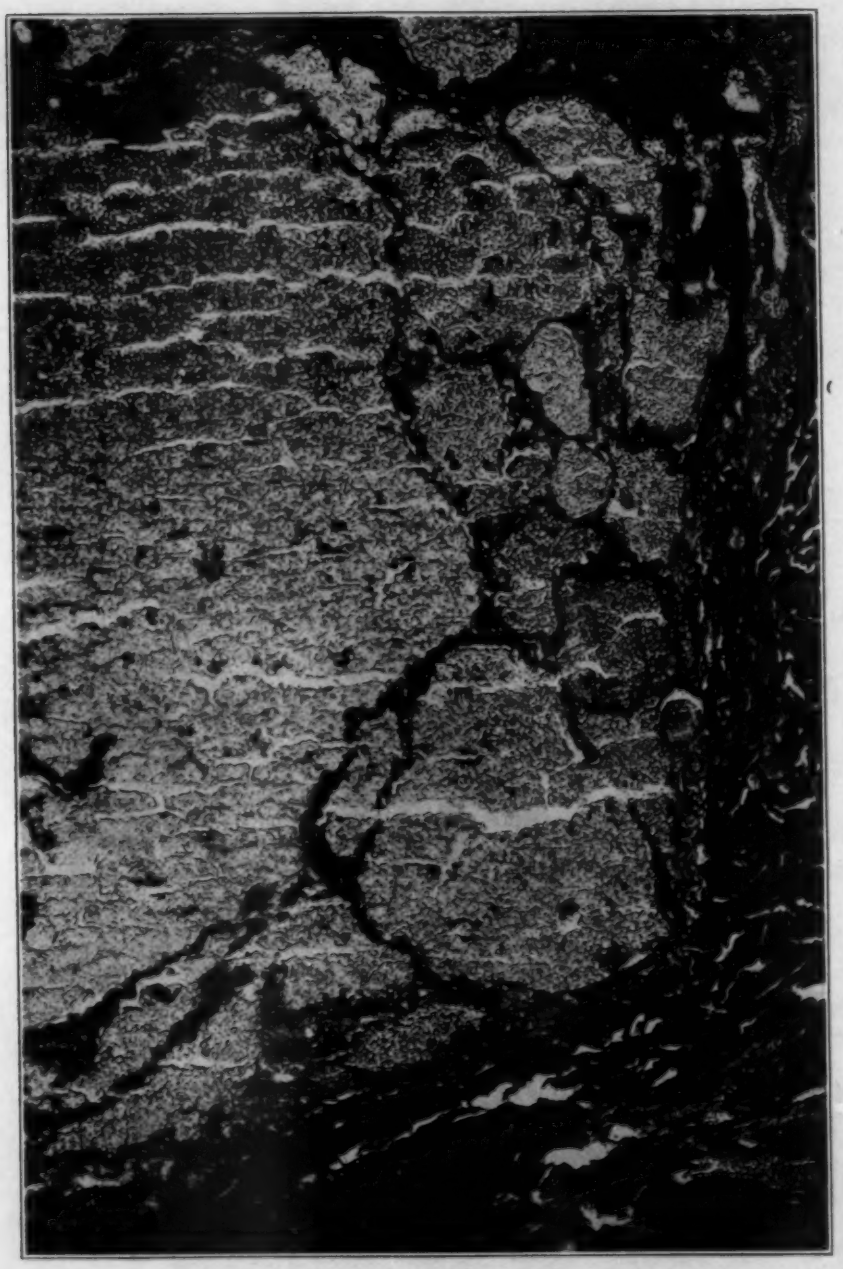

Fig. 2 (case 24).—Photomicrograph of the tumor showing large cavernous spaces filled with red blood cells; × 125. The endothelial septums separating the blood spaces are well demonstrated.

Fig. 3.—Photomicrograph of the tumor showing a large mass of living bone with adjacent fibrous tissue, and on one side small cavernous spaces containing red blood cells; × 310.

elbow. He first noticed this while trying on a new coat. He had no pain until six months later, when there was a sudden onset of soreness, which lasted only a day or so. Again three weeks before admission there was considerable pain, and the arm was put in a cast for a week. On admission to the hospital there was marked tenderness over the head of the radius with marked interference with motion, but no tumor was palpable. On Aug. 16, 1935, the lateral epicondyle of the right humerus was exposed with the patient under general anesthesia. A soft vascular tumor about the size of a marble was found just anterior to the humerus, extending into the elbow joint, and was removed. It was situated so that flexion of the elbow would cause compression of the tumor. Histologic examination revealed a cavernous hemangioma. No recurrence was noted five weeks later, and there was marked increase in the range of motion of the elbow and no pain. The clinical diagnosis was cavernous hemangioma of the capsule of the right elbow joint.

The other case was that of D. M., a schoolgirl aged 11 years, who had a lump over the cord of the right heel for nine years. This had increased gradually in size during the past few years and was painful during the eight months preceding operation. It was slightly tender and elevated. It was not attached to the skin but seemed to be connected to the achilles tendon. The overlying skin was not discolored. The growth was 5 cm. above the insertion of the achilles tendon and measured 5 by 4 by 2.5 cm. Roentgen examination revealed a swelling of the soft tissue but no phleboliths. The mass was excised by Dr. C. H. Hatcher on July 23, 1934, and at operation was found to be only 2 cm. in diameter and connected with large subcutaneous veins and to the sheath of the achilles tendon. Histologic examination showed a cavernous hemangioma. There was no recurrence eight months later. The clinical diagnosis was cavernous hemangioma of the sheath (?) of the right achilles tendon.

COMMENT

Hemangioma of a tendon or of a tendon sheath is quite rare. Weil [6] in 1913 collected reports of six such cases; Burman and Milgram [1] in 1930 were able to collect reports of sixteen; Botto Micca [12] in 1934 raised the total to nineteen, and in the present article twenty-four such cases are assembled. Hemangioma arising in a muscle is, on the other hand, much more common. Jenkins and Delaney [23] in 1932 collected two hundred and fifty-six such cases, and Nicolosi [24] and others have

23. Jenkins, H. P., and Delaney, P. A.: Benign Angiomatous Tumors of Skeletal Muscles, Surg., Gynec. & Obst. **55**:464-480 (Oct.) 1932.

24. Nicolosi, Gioacchino: Sugli emangiomi primitivi dei muscoli striati, Riv. san. siciliana **22**:32-41 (Jan. 1) 1934.

reported similar ones during the past three years. That hemangiomas of a tendon or of a tendon sheath comprise only a small fraction of all tumors of such origin is seen by a study of several reviews of all types of tumor of a tendon. King,[25] in his review of the pathologic structure of tumors of tendon sheaths, makes no mention of hemangioma. Tison and Hubert [26] referred to only one case of angioma in their review of the same subject. Morton's [13] case as well as that of Janik,[8] referred to earlier in this article, is taken from a large series of various types of tendon tumors. Lewis,[27] in reviewing the subject of tumor of a tendon sheath mentioned several types of tumor that have been reported in much greater numbers than the hemangioma considered in the present article. Ganglions of tendon sheaths are admittedly common. Lewis has reported over two hundred cases of giant cell tumor (xanthoma) of a tendon sheath, fifty of which were from his own laboratory of surgical pathology. He also found benign osteochondroma of a tendon quite common.

A study of the twenty-four cases of hemangioma of a tendon or of a tendon sheath reviewed in the present article reveals that in ninteen instances in which the sex was stated there were twelve females and seven males. The side on which the tumor occurred was stated in eighteen instances, the left being involved ten times and the right eight times. This does not indicate the marked preponderance of left-sided involvement mentioned by Burman and Milgram.[1] The upper extremity was involved thirteen times and the lower seven times. This is in opposition to the selective localization of hemangioma of the muscle in the lower extremity, as noted by Jenkins and Delaney.[23]

Observation of change in size on elevation and depression of the limb and after application of a constrictor is of importance in the diagnosis. Roentgen examination, as in the case of hemangioma of the muscle,[23] will often reveal multiple calcified phleboliths. Positive findings in this regard were reported in five of the twenty-four cases (6, 10, 15, 18 and 24), as well as in Bouquet's case of hemangioma of a muscular aponeurosis. In only one instance (case 19) were no phleboliths found on roentgen examination. Pathologic examination, as in the case of hemangioma elsewhere in the body, cannot always clearly differentiate between the predominance of endothelial, of fibrous and of hemangiomatous involvement. Likewise, the line of demarcation between lymphangioma and hemangioma and also between capillary and cavernous

25. King, E. S. J.: Concerning the Pathology of Tumours of Tendon Sheaths, Brit. J. Surg. **18**:594-617 (April) 1931.

26. Tison, P., and Hubert, J.: Les tumeurs des gaines tendineuses, Echo méd. du nord **1**:943-953 (June 17) 1934.

27. Lewis, Dean: Tumors of Tendon Sheaths, Surg., Gynec. & Obst. **59**:344-349 (Sept.) 1934.

hemangioma must often be arbitrary. Three definite recurrences are mentioned (cases 4, 9 and 19), as well as two instances in which the operative removal was possibly not complete (cases 10 and 24). Surgical treatment, however, seems to be fairly efficacious, although many of the reported cases were not followed long enough to rule out recurrence.

CONCLUSIONS

A case of hemangioma of the flexor tendons of the wrist in a young woman is reported. Twenty-three other instances of hemangioma arising from a tendon or a tendon sheath are collected from the literature, making a total of twenty-four such cases. Hemangioma of this origin has a relatively benign clinical course, and operative removal seems to be the most efficacious form of treatment.

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PLATYSPONDYLY

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Platyspondyly is a congenital anomaly consisting essentially of a widening of the vertebral body, as is indicated by its derivation from the Greek terms *platy* meaning wide and *spondylos* signifying vertebra. This designation was coined in 1910 by Putti, who was the first to describe the deformity. The lesion was previously mentioned by Nau (1904) in his thesis on "Congenital Scoliosis," in which he described it as a widened bilobar vertebra. Subsequent to Putti's work, little mention was made of this anomaly save in the theses of Chevrier (1912) and Breton (1921). In 1927 Lance reported eight cases of this condition and definitely established it as a clinical entity. Further observations of this anomaly were made in France by Mouchet, Mauclaire, Botreau-Roussel, Clavelin, Tavernier and Massias. A search of the American and English literature failed to reveal a single report of this maldevelopment. Since I had the good fortune to encounter several instances of platyspondyly, I take the opportunity to report them and to discuss the pathogenesis, the clinical and roentgenographic appearances and the differential diagnosis of this condition.

For a clear understanding of this maldevelopment it is necessary to consider the embryology of the spine in its membranous, cartilaginous and osseous stages. The following description is based largely on the work of Bardeen.

EMBRYOLOGY OF THE VERTEBRAE

At a very early period in the development of the human embryo a layer of mesoderm appears between the ectoderm and the entoderm in the midsagittal plane. This mesodermal layer soon disappears from the region beneath the neural tube. Possibly it becomes incorporated with the entoderm in this region, which at this time presents a plate of tissue slightly thicker than its continuation on either side. This thickened entodermal plate is the chordal plate, which soon becomes pinched off from the entoderm to form the chorda dorsalis, about which the vertebrae and the intervertebral disks subsequently develop. Just

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before ossification of the vertebral bodies the chorda dorsalis disappears in its entirety, save for small fragments which remain to form the nuclei pulposi of the intervertebral disks.

At the time that the mesoderm disappears from the region of the chordal anlage, its lateral prolongations become divided into a series of segments known as mesoblastic somites. Concomitantly with the differentiation of the chorda dorsalis, the mesoblastic somites undergo a change. For a time, these consist of epithelial tissue which surround a central cavity known as the myocele. Toward the end of the third week of embryonic life, the myoceles become gradually filled with branched spindle-shaped mesenchymal cells derived from the surrounding epithelium. The medial walls of the mesoblastic somites open, and the mesenchymal cells wander out toward the neural tube and chorda dorsalis, giving rise to a mass of tissue which ensheathes these structures. The mass of mesenchyme derived from each of these somites represents a sclerotome. The successive sclerotomes soon fuse so as to form a continuous mass of mesenchyme, one on each side, thus giving rise to the membranous stage in the embryonic development of the spine.

The division of the axial mesenchyme into segments which are known as sclerotomes, and which correspond to the myotomes, is marked off at an early stage by intersegmental arteries. At this time each sclerotome becomes divided into two portions, a caudal half and a cranial half. A slight fissure—the intersegmental fissure—may partially separate the two halves. From the caudal half arises the primitive vertebra of Remak, or scleromere, with dorsal (neural), ventral (costal) and chordal processes. The latter unite these structures to the perichordal sheath, which is a dense membrane about the chorda dorsalis. From the cranial halves of the sclerotomes arise the interdorsal membranes, which unite the dorsal (neural) processes, and the interventral membranes, which unite the ventral (costal) processes. The chordal processes give rise to the primitive intervertebral disks. The tissue lying between each two disks now becomes completely surrounded by a membrane, the interdiskal membrane. Meanwhile the perichordal sheath between each two disks becomes extended ventrodorsally, so that it gives rise to a perichordal septum, which divides into two parts the space surrounded by the interdiskal membrane.

The cartilaginous stage begins at this time with the appearance at about the same time in the aforementioned membranous vertebra of six primary centers of chondrification, one for each costal process, one for each neural arch and one for each half of the vertebral body. The costal processes do not retain their connection with the body of the vertebra but soon break away to form rib cartilages. At first

the cartilage of one side of the vertebra, which is formed by a transformation of the loose tissue lying between the primitive intervertebral disks surrounded by the interdiskal membrane, is separated from that of the other side by the perichordal septum. This is soon broken through, and the two cartilaginous anlagen of the vertebral body become united about the chorda. Processes then grow out from the vertebral arch to form transverse and articular processes, and each half of the vertebral arch meets its fellow of the opposite side to form a spinous process.

The osseous stage begins with the appearance of centers of ossification for the neural arches and costal processes in correspondence with the original cartilaginous centers. The centers of ossification of the bodies in most of the vertebrae show little evidence of the bilateral origin of the centers of chondrification.

For the purposes of this paper it is necessary to note the following phases in the membranous stage of the embryologic development of the spinal axis: (1) the division of the axial mesenchyme into sclerotomes equal in number to and corresponding with the myotomes; (2) the subdivision of each sclerotome into a cranial and a caudal portion; (3) the fusion of the cranial and caudal halves of the adjoining sclerotomes to form the primitive vertebrae; (4) the presence of the perichordal septum which divides each vertebral anlage into two lateral halves, and (5) the fusion of the lateral halves to form the final vertebra. It is therefore evident from the foregoing data that aberrations of the processes of axial segmentation or subsequent fusion will cause anomalies of differentiation, morphology and numerical variations. Furthermore, failure or delay of fusion of the lateral halves causes hemivertebrae and the three types of platyspondyly to be described later.

PATHOGENESIS OF PLATYSPONDYLY

Putti noted the maldevelopment under discussion only in the fourth and fifth lumbar vertebrae. In each instance it was associated with spina bifida, i. e., failure of fusion of the posterior arch. His explanation of this characteristic appearance is that it is caused by an actual widening of the vertebral body in addition to an apparent widening of the body due to the shadows cast by the articular and transverse processes resulting from the spreading of the neural arches, because of failure of union of the lateral halves of the neural arches at the spinous processes. Perussia in his case report agreed with Putti's explanation of this congenital anomaly.

Lance, however, noted this maldevelopment in other regions of the spine, in association at times with spina bifida and somatoschisis, i. e., a failure of fusion of the lateral halves of the vertebral bodies. He

also reported two cases of total involvement of the spine. Lance expressed the belief that this anomaly is caused by a failure or a delay of fusion of the lateral halves of the vertebral anlagen in the membranous stage of their embryologic development. Thus a failure of fusion of the posterior arches causes spinal bifida, and a failure of fusion of the vertebral bodies causes somatoschisis, while a delay of fusion causes the widening of the vertebral bodies with their characteristic appearances, to be described later. With this developmental basis for his theory, Lance was enabled to classify this anomaly into several types.

It appears to me and to most contributors to this subject that Lance's conception of platyspondyly explains all the variations of this condition and is in harmony with the results of embryologic studies. Putti's views on the pathogenesis are insufficient, because he did not include the various forms of this condition. Furthermore, spina bifida occulta and spina bifida completa are not necessarily accompanying anomalies. It is also pointed out that spina bifida may occur in the same embryonic (membranous) stage as somatoschisis or during the ossific stage. In the former case it is the result of the same cause as platyspondyly, but if it occurs merely as a result of failure of bone fusion it is a result rather than the cause of platyspondyly.

The three types of platyspondyly described by Lance present the following picture:

Type 1. The anomaly of this type consists of a widened vertebra, thickened, adjacent vertebral disks and spina bifida, as described by Putti. This form is localized and usually involves the fourth and fifth lumbar vertebrae.

Type 2. In this type there is a widened vertebral body which is divided into two cuneiform segments, with their apexes placed centrally and their bases laterally. This anomaly may or may not be associated with spina bifida. In this type spina bifida and somatoschisis are rarely limited to one segment and are associated with anomalies in number, regional differentiation and fusions of vertebrae. Platyspondyly of this type is most common in the dorsal and cervicodorsal regions of the spine. In such cases the shape of the intervertebral disks is the counterpart of the shape of the vertebrae.

Type 3. In this type the superior and inferior surfaces of the vertebral bodies are concave in the center, as seen in the anteroposterior views, while the intervertebral disks are convex and proportionally higher than normal. Such an anomaly may be limited to several vertebrae or may involve the entire spine.

DESCRIPTION OF TYPES OF PLATYSPONDYLY

Type 1, which is characterized by a widened vertebra, diminished vertical diameter and spina bifida posterior, is usually limited to the

fourth and fifth lumbar segments. The adjacent intervertebral disks are usually increased in height. The instances of this type are usually discovered accidentally. A person with this type of platyspondyly has a potentially weak back, and may present neurotrophic symptoms due to the spina bifida. This type may, or more often may not, be accompanied by other congenital anomalies. Marziani found this form of platyspondyly in 17 per cent of his cases of spina bifida. Cases 1 to 5, inclusive, that are reported here are examples of this group.

Type 2, the localized form described by Lance, which presents somatoschisis with or without spina bifida, is characterized clinically by weakness of the back, vague pains and varying degrees of deformities of the spine found in congenital scoliosis and kyphosis. This form is usually localized at the cervicodorsal and dorsal regions and is often associated with spinal anomalies of differentiation, morphology and number. It may also be associated with congenital maldevelopments of the ribs, elevated scapulae (Sprengel's deformity) and the short neck syndrome (Klippel-Feil's syndrome). At times there may be found neurotrophic disturbances due to the spina bifida. When the deformities are severe, death occurs during fetal life. It would seem, from my observation of the many case reports in which platyspondylitic anomalies are recorded without being named as such, that this form is much more common than is indicated in the literature. It is true that this may be merely of academic import; nevertheless, it is important to recognize this type, so as to form a complete picture with those forms of platyspondyly that are of clinical importance. Cases 6 to 13, inclusive, are illustrative of this type.

Type 3 is present clinically in two forms, the generalized and the localized form. The generalized form is rare. Lance described two cases. Tavernier and Massias reviewed these and added two more instances. Marziani added another case, and Benoiste-Pilloire and Gourdon added still another. In all, six cases have been described heretofore. I am reporting five additional cases (cases 13 to 17, inclusive). This type of platyspondyly is a distinct clinical entity and can be readily recognized by its roentgenographic appearance. The clinical picture, however, may at times be so definite as to suggest this condition. The outstanding and practically the only symptom is an unusual flexibility of the spine, noted in infancy, so much so that the patient cannot stand without support. In the sitting position the infant presents a long posterior curve and a forward inclination of the body because of inability to support the head and trunk. Roentgenographically, the picture is equally characteristic. The anteroposterior roentgenograms show all of the vertebral segments to be abnormally widened, their vertical diameters lessened by one half to one third of the normal

height and their superior and inferior vertebral outlines concave in the midregion. At the same time the intervertebral disks are correspondingly increased in height, and their superior and inferior surfaces are convex to correspond to the vertebral concavities. The entire picture has the appearance of alternating biconvex, abnormally high, wide and clear disks with biconcave, abnormally wide, low and darker segments—the vertebral bodies. The lateral views show little save the disproportion in the vertical diameters of the disks and bodies. The outlines of the vertebrae and disks are sharp and clear, and their texture is normal in appearance. This type usually presents no other roentgenographic congenital abnormalities. Benoiste-Pilloire and Gourdon's case is exceptional in that in addition to the spinal maldevelopment there was bilaterally an absence of all of the bones of the wrists, absence of the tarsal scaphoid and two cuneiform bones, enlargement of the acetabula and a trophic disturbance of the head of the femurs.

The localized form is also distinct and presents an appearance similar to the generalized form, save that the lesion is localized to one or more segments of the spine. These segments may appear occasionally as fusiform widenings of the spine, with the greatest widths at the center and a gradual diminution of the width as the upper and the lower pole of the segments are approached. If the lesion is at the upper or lower end of the spine, the appearance may be that of a half of a fusiform swelling, with the greatest width at either the upper or the lower end of the spinal column. The characteristic concavities on the superior and inferior surfaces of the vertebral bodies are not likely to be as well marked as in the generalized form. The localized form is likely to be associated with cervical ribs, hypertrophied transverse processes of cervical vertebrae and failure of descent of one or both scapulae. Clinically, they are symptomless per se. Cases 18 to 39, inclusive, are examples of this form.

It is not to be assumed that this classification into types is clearcut. The most distinct groups are type 2 and the generalized form of type 3. The differentiation of type 1 from the localized form of type 3 may sometimes be arbitrary, as will be shown by cases 18 and 19, in which there was a combination of both subdivisions.

Marziani agreed with the foregoing conceptions only so far as types 1 and 2 are concerned. According to him, type 3 is a microspondyly of chondrodystrophic or osteochondropathic origin, associated with a flattening of the vertebral bodies rather than with true congenital platyspondyly. Marziani, however, failed to explain how the typical concavities of the superior and inferior vertebral borders are produced in the so-called instances of chondrodystrophy and osteochondropathy. I have noted several forms of chondrodystrophy with

a generalized platyspondyly, but these can be readily differentiated, as will be noted later. Furthermore, no instance of generalized osteochondropathy of the spine has ever been noted. The localized forms can be readily differentiated, as will be indicated in the following discussion.

DIAMETERS OF NORMAL VERTEBRAE

It is opportune at this point to consider the normal ratios of the transverse diameters to the vertical diameters of the various vertebrae and their relations to each other. An extensive search of the literature revealed but few references to this subject. Alban Kohler stated that beginning with the first cervical segment each successive vertebral body is higher than, or at least equal in height to, the one above it. Any lessening of the vertical diameter in a caudal segment is pathologic. This, he stated, holds true for all vertebrae, with the exception of the fifth lumbar segment. Hans Jacobi, of Schmorl's Clinic, on the basis of his measurements of one hundred and two spines, including the first dorsal to the third lumbar segments, of persons between the ages of 18 to 87, stated that each caudal vertebra is higher than the one above it, save the sixth dorsal segment, which is 1 mm. less than the fifth dorsal vertebra. Anderson quoted Henle to the effect that the vertical diameter increases from the third cervical to the last lumbar vertebra. On the basis of his own measurements of anatomic material, he found that the fifth dorsal vertebra has the smallest transverse diameter and that a gradual increase in the transverse diameter takes place from the second cervical to the second dorsal vertebra, followed by a gradual increase to the fifth lumbar segment. He also appended a table of the means of the transverse and the vertical diameters of the bodies of fifty-three vertebral columns. I have calculated the ratios of the transverse diameters to the vertical diameters as shown in table 1. Cyriax is the most recent writer to measure a series of vertebral columns. He also gave the transverse and vertical means of anatomic material. I have reduced these to the ratios of the transverse to the vertical measurements, as shown in table 1.

A consideration of this material has shown it to be insufficient for my purposes, for the aforementioned authors did not consider the variations that might possibly exist at various ages. In fact, the age variant was not mentioned by these writers. Furthermore, their observations were made on anatomic material, while the present study is based on roentgenographic appearances. I felt, therefore, that it was incumbent on me to make measurements on roentgenograms of normal spines at various ages. One hundred and forty-five series of roentgenographic films of whole or partial spines were measured in the anteroposterior and lateral views. Since only ratios are being con-

sidered, the variant of distance of exposure is of no consequence. The one hundred and forty-five spines were divided into six age groups —birth to 1 year of age, 1 to 6 years, 6 to 11 years, 11 to 16 years, 16 to 22 years and 22 years of age and over, as shown in table 2.

TABLE 1.—*Ratios of the Transverse Diameters to the Vertical Diameters of Normal Vertebral Bodies*

Author	Cyriax	Anderson*	Buchman
Age	Adult	Adult	22 and Over
Material	Autopsy	Autopsy	Roentgenograms
C- 1	...	...	...
C- 2	...	1.0	...
C- 3	1.6	1.6	1.8 (4)†
C- 4	1.7	1.8	1.9 (7)
C- 5	1.9	1.9	1.9 (8)
C- 6	2.1	2.2	2.0 (10)
C- 7	2.2	2.1	2.0 (12)
D- 1	2.0	1.8	1.8 (14)
D- 2	1.8	1.7	1.8 (16)
D- 3	1.7	1.5	1.6 (15)
D- 4	1.5	1.4	1.4 (11)
D- 5	1.5	1.4	1.5 (11)
D- 6	1.5	1.5	1.5 (12)
D- 7	1.5	1.5	1.5 (12)
D- 8	1.6	1.5	1.5 (12)
D- 9	1.5	1.5	1.6 (12)
D-10	1.6	1.6	1.5 (12)
D-11	1.7	1.5	1.5 (14)
D-12	1.6	1.6	1.5 (14)
L- 1	1.6	1.7	1.4 (19)
L- 2	1.6	1.7	1.4 (19)
L- 3	1.6	1.8	1.5 (19)
L- 4	1.7	1.9	1.6 (19)
L- 5	1.7	2.1	1.8 (11)

* Anderson's work is based on fifty-three spines.
† The numbers in parenthesis indicate number of observations.

TABLE 2.—*Ratios of the Transverse Diameters to the Vertical Diameters of Normal Vertebral Bodies* *

Age Group	Birth to 1 Year	1 to 6 Years	6 to 11 Years	11 to 16 Years	16 to 22 Years	22 Years and Over
C- 2	1.9 (6)†	.....	1.7 (1)	2.2 (1)	.....	.....
C- 3	2.1 (11)	.....	2.2 (1)	2.2 (1)	2.1 (3)	1.8 (4)
C- 4	2.0 (11)	2.0 (1)	2.3 (1)	2.4 (7)	1.9 (6)	1.9 (7)
C- 5	1.9 (13)	2.0 (1)	2.3 (3)	2.5 (9)	1.9 (7)	1.9 (8)
C- 6	2.0 (12)	2.3 (2)	2.2 (7)	2.4 (12)	2.2 (9)	2.0 (10)
C- 7	2.1 (12)	2.3 (3)	2.2 (9)	2.2 (15)	2.2 (11)	2.0 (12)
D- 1	2.1 (12)	2.1 (5)	2.2 (10)	2.2 (19)	2.0 (10)	1.8 (14)
D- 2	2.2 (13)	2.1 (7)	2.2 (10)	2.0 (20)	1.9 (11)	1.8 (16)
D- 3	2.3 (14)	2.0 (11)	1.9 (13)	1.7 (20)	1.7 (11)	1.6 (15)
D- 4	2.2 (15)	1.9 (11)	1.8 (13)	1.6 (21)	1.5 (9)	1.4 (11)
D- 5	2.5 (17)	1.9 (11)	1.7 (12)	1.5 (22)	1.4 (8)	1.5 (11)
D- 6	2.4 (21)	1.8 (11)	1.8 (12)	1.5 (23)	1.4 (8)	1.5 (12)
D- 7	2.5 (23)	1.8 (11)	1.7 (13)	1.5 (25)	1.4 (9)	1.5 (12)
D- 8	2.5 (27)	1.8 (12)	1.8 (13)	1.5 (23)	1.5 (8)	1.5 (12)
D- 9	2.5 (28)	1.9 (12)	1.8 (14)	1.5 (23)	1.5 (9)	1.6 (12)
D-10	2.3 (30)	1.9 (13)	1.8 (14)	1.6 (23)	1.5 (9)	1.5 (12)
D-11	2.3 (36)	1.9 (14)	1.9 (14)	1.6 (23)	1.5 (12)	1.5 (14)
D-12	2.3 (38)	1.9 (14)	1.9 (14)	1.6 (24)	1.4 (12)	1.5 (14)
L- 1	2.2 (39)	1.8 (14)	1.7 (14)	1.6 (24)	1.4 (14)	1.4 (19)
L- 2	2.1 (39)	1.8 (14)	1.8 (12)	1.6 (25)	1.4 (15)	1.4 (19)
L- 3	2.2 (39)	1.9 (14)	1.8 (11)	1.6 (21)	1.4 (13)	1.5 (19)
L- 4	2.2 (35)	1.9 (14)	1.9 (10)	1.7 (18)	1.6 (12)	1.6 (19)
L- 5	2.3 (29)	2.1 (10)	1.9 (5)	2.0 (6)	1.7 (5)	1.8 (11)

* Calculated from my measurements on roentgenograms of one hundred and forty-five patients.
† The numbers in parenthesis indicate the number of observations.

A comparison of the ratios obtained for the spines of patients 22 years of age and over with the ratios obtained from the observations of Cyriax and Anderson, which I feel justified in assuming to be based on adult material, shows insignificant variations which are not greater than those found between the figures of the latter authors (table 1). It is therefore apparent that the ratios obtained from the measurements of transverse and vertical diameters on roentgenograms are sufficiently accurate for practical purposes. It is to be noted that beginning with the second cervical segment the ratio increases gradually to the sixth and seventh cervical vertebrae, and then there is diminution, which reaches its maximum at the fourth and fifth dorsal segments, to be followed by an increase in the ratio of transverse and vertical measurements, reaching a maximum at the fifth lumbar vertebra. The greatest ratio obtained in these three sets of observations is 2.2 for the sixth cervical segment.

A study of the figures for the other groups of patients (table 2) shows that the ratios are highest for the age group from birth to 1 year. These ratios decrease until the adult age is reached.

MEASUREMENTS OF NORMAL VERTEBRAL DISKS

Greater difficulties were met in an attempt to learn the normal ratios of the heights of the intervertebral disks to the vertebral bodies and their relationship to one another. A study of the literature revealed only general statements, as those of Piersol, who stated in his "Human Anatomy" that the disks form 40 per cent of the cervical region, 20 per cent of the thoracic segment and 33 per cent of the lumbar portion of the spine. Hans Jacobi is the only author who to my knowledge presented detailed data based on measurements of a large series of spines (one hundred and two) removed at autopsy, including the region between the first dorsal and the third lumbar segment, as shown in table 3.

I considered these data insufficient, for Jacobi was concerned with anatomic material while my study is based on roentgenographic appearances. I, therefore, made measurements and calculated the ratios for the various age groups (table 4).

A comparison of the measurement of the spines of patients 22 years of age and over with the measurements of Jacobi show slight variations. I feel, nevertheless, that roentgenographic measurements of disks cannot be accurate, for there are several factors of error owing to the smallness of the measurements and the variations in the shape of disks resulting from positions of flexion and extension and variations incidental to points of measurements. I therefore look on the figures as only approximately correct.

A study of the ratios obtained for the younger age groups reveals that here also these ratios are greatest for the age group from birth to 1 year and that these ratios decrease until an adult age is reached (table 4).

TABLE 3.—*Ratios of the Vertical Diameters of the Subjacent Intervertebral Disks to the Vertical Diameters of Normal Vertebral Bodies*

Author	Jacobi*	Buchman
Material	Autopsy	Roentgenograms
Age	Adult	22 Years and Over
C- 1	....	.....
C- 2	....	.....
C- 3	....	0.4 (2)†
C- 4	....	0.4 (3)
C- 5	....	0.45 (3)
C- 6	....	0.4 (3)
C- 7	....	0.3 (5)
D- 1	0.28	0.2 (3)
D- 2	0.23	0.25 (4)
D- 3	0.21	0.2 (4)
D- 4	0.20	0.2 (5)
D- 5	0.20	0.2 (5)
D- 6	0.21	0.2 (6)
D- 7	0.20	0.2 (6)
D- 8	0.24	0.25 (6)
D- 9	0.24	0.25 (6)
D-10	0.25	0.25 (6)
D-11	0.25	0.25 (8)
D-12	0.27	0.3 (8)
L- 1	0.32	0.3 (9)
L- 2	0.38	0.3 (10)
L- 3	0.37	0.3 (10)
L- 4	....	0.3 (10)
L- 5	....	0.3 (5)

* Jacobi's work is based on one hundred and two spines.
† The numbers in parenthesis indicate the number of observations.

TABLE 4.—*Ratios of the Vertical Diameters of the Subjacent Intervertebral Disks to the Vertical Diameters of Normal Vertebral Bodies**

Age Group	Birth to 1 Year	1 to 6 Years	6 to 11 Years	11 to 16 Years	16 to 22 Years	22 Years and Over
C- 1	.....	.....	.....	.....	.....	.....
C- 2	0.4 (5)†	.....	.....	.....	.....	.....
C- 3	0.4 (7)	.....	.....	.....	.....	.....
C- 4	0.4 (8)	.....	.....	0.5 (2)	0.4 (1)	0.4 (3)
C- 5	0.3 (9)	.....	0.3 (1)	0.4 (3)	0.4 (1)	0.45 (3)
C- 6	0.4 (10)	.....	0.3 (2)	0.4 (3)	0.4 (2)	0.4 (3)
C- 7	0.4 (10)	.....	0.3 (4)	0.3 (3)	0.4 (4)	0.3 (5)
D- 1	0.4 (10)	0.3 (3)	0.3 (4)	0.3 (4)	0.3 (3)	0.2 (3)
D- 2	0.5 (11)	0.3 (4)	0.3 (8)	0.2 (6)	0.3 (3)	0.25 (4)
D- 3	0.5 (12)	0.3 (6)	0.2 (9)	0.2 (7)	0.3 (3)	0.2 (4)
D- 4	0.5 (13)	0.3 (7)	0.2 (9)	0.2 (7)	0.3 (4)	0.2 (5)
D- 5	0.6 (15)	0.3 (7)	0.3 (10)	0.2 (7)	0.3 (4)	0.2 (5)
D- 6	0.6 (19)	0.3 (7)	0.3 (10)	0.2 (10)	0.2 (5)	0.2 (6)
D- 7	0.5 (21)	0.3 (7)	0.2 (10)	0.2 (10)	0.2 (5)	0.2 (6)
D- 8	0.4 (25)	0.3 (8)	0.3 (10)	0.2 (10)	0.2 (5)	0.25 (6)
D- 9	0.45 (26)	0.3 (8)	0.2 (11)	0.2 (10)	0.2 (6)	0.25 (6)
D-10	0.4 (28)	0.3 (9)	0.3 (11)	0.2 (10)	0.2 (6)	0.25 (6)
D-11	0.4 (34)	0.3 (9)	0.3 (11)	0.2 (10)	0.3 (6)	0.25 (8)
D-12	0.4 (36)	0.3 (9)	0.3 (11)	0.3 (9)	0.3 (7)	0.3 (8)
L- 1	0.4 (37)	0.3 (9)	0.4 (10)	0.3 (8)	0.3 (7)	0.3 (9)
L- 2	0.4 (37)	0.4 (9)	0.4 (7)	0.3 (8)	0.3 (8)	0.3 (10)
L- 3	0.4 (37)	0.4 (9)	0.5 (7)	0.4 (6)	0.3 (7)	0.3 (10)
L- 4	0.4 (35)	0.4 (9)	0.5 (5)	0.4 (5)	0.3 (6)	0.3 (10)
L- 5	0.3 (24)	0.4 (4)	0.4 (5)	0.4 (2)	0.3 (2)	0.3 (5)

* Calculated from my measurements on roentgenograms of one hundred and forty-five patients.
† The numbers in parenthesis indicate the number of observations.

MEASUREMENTS OF THE VERTEBRAL AND INTERVERTEBRAL DISKS IN PLATYSPONDYLY

Table 5 represents the ratios obtained in thirty-eight cases of platyspondyly and is indicative, as is evidenced by the increase in the ratios, of the disturbance in the relationship between the transverse and the vertical diameter of these patients. This disturbance becomes self-apparent when compared with the normal ratios for the various age groups given in tables 2 and 4.

Fig. 1 (case 1).—Platyspondyly, type 1. In *A*, the fifth and to a lesser extent the fourth lumbar vertebra are widened transversely. In *B*, the vertical diameter of the fifth lumbar vertebra is less than normal.

CASES OF TYPE 1

CASE 1.—A. H., an American-born white boy, 12 years of age, was admitted to the service of Dr. Samuel Kleinberg at the Hospital for Joint Diseases because of multiple foci of osteomyelitis, among which was included the left sacro-iliac joint.

As an incidental finding, spina bifida occulta of the fifth lumbar vertebra was noted in the anteroposterior roentgenogram (fig. 1 *A*). The fifth vertebral segment and, to a lesser extent, the fourth, were widened transversely. The lateral view (fig. 1 *B*) showed distinctly the lessening of the vertical diameter of the fifth lumbar vertebra.

TABLE 5.—*Ratios of the Transverse Diameters to the Vertical Diameters of the Vertebral Bodies and Ratios of the Vertical Diameters of the Subjacent Intervertebral Disks to the Vertical Diameters of the Vertebral Bodies in Platyspondyly* *

Case	1		2		3		4		5		6		7		8		9		10		11		12	
Age	12 Years		5 Years		5 Years		6 Years		12 Years		5 Years		10 Months		14 Years						18 Years		7 Years	
	Vert.	Disk	Vert.	Disk	Vert.	Disk	Vert.	Disk	Vert.	Disk	Vert.	Disk.	Vert.	Disk	Vert.	Disk	Vert.	Disk	Vert.	Disk	Vert.	Disk	Vert.	Disk
C- 2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3.7	..
C- 3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5.0	..	..	..	..	..	3.7	..
C- 4	..	..	..	..	..	..	..	..	..	..	..	..	7.6	0.7	..	..	5.0	..	..	..	..	..	3.3	..
C- 5	..	..	..	..	..	..	..	..	..	..	..	..	5.8	0.5	2.2	..	5.0	..	5.2	..	..	..	..	..
C- 6	..	..	..	..	..	..	..	..	..	..	..	..	4.6	0.4	4.8	..	3.6	..	3.7	..	..	..	2.9	..
C- 7	..	..	..	..	..	..	..	..	..	..	..	..	3.1	0.3	2.8	..	3.9	..	3.4	..	..	..	3.0	..
D- 1	..	..	..	..	..	..	..	..	..	..	..	..	4.0	0.4	2.0	..	4.2	..	4.3	..	..	..	2.5	..
D- 2	..	..	..	..	..	..	..	..	..	..	..	..	3.2	0.5	2.6	..	7.6	..	2.8	..	..	..	1.7	..
D- 3	..	..	..	..	..	..	..	..	..	..	..	..	2.8	0.5	..	..	3.6	..	2.1	..	..	..	..	..
D- 4	..	..	..	..	..	..	..	..	..	..	..	..	2.3	0.4	..	..	2.8	..	2.2	..	..	..	..	..
D- 5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1.7	..	..	..	1.8	..	..	..	..	..
D- 6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1.5	..	..	..	1.6	..	..	..	..	..
D- 7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1.6	..	..	..	2.5	..	..	..	..	..
D- 8	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1.5	..	..	..	1.9	..	..	..	..	..
D- 9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2.7	..	1.5	..	..	..
D-10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2.7	..	1.6	..	..	..
D-11	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2.1	..	1.7	..	..	..
D-12	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1.8	..	1.8	0.1	..	..
L- 1	1.7	1.2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1.8	..	1.6	0.1	..	..
L- 2	1.7	0.3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1.4	0.1	..	..
L- 3	1.9	0.4	1.8	0.3	1.3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1.5	0.1	..	..
L- 4	2.0	0.4	2.6	0.5	1.8	0.4	3.3	0.7	1.9	0.3	..	..	..	..	..	..	..	..	..	..	2.1	0.1	..	..
L- 5	2.5	0.4	2.8	0.4	2.4	0.5	3.4	0.7	2.9	0.5	..	..	..	..	..	..	..	..	..	..	3.1	..	..	..
Comment	Spina bifida occulta of L-5				Spina bifida occulta of upper sacral segments				Spina bifida occulta of L-5 and S-1				Cervical rib at C-7; somatoschisis of C-5, 6, 7		Congenital scoliosis; fusion of D-3 and D-4		Hemivertebra between C-6 and C-7; bilateral Sprengel's deformity		Bilateral cervical ribs; seventh rib atrophic; spina bifida occulta of D-6, 7 and 8; somatoschisis of D-10		Fusion of anterior halves of D-12, to and including L-4; spina bifida occulta of S-1		Hypertrophied transverse processes of C-7; somatoschisis of C-5; congenital torticollis	

Case	13		14		15		16		17		18		19		20		21		22		23		24	
Age	3½ Years		20 Months		2 Years		12 Months		18 Months		6 Years		6½ Years		9 Years		8 Years		7 Years		3½ Years		8 Years	
	Vert.	Disk	Vert.	Disk	Vert.	Disk	Vert.	Disk	Vert.	Disk	Vert.	Disk.	Vert.	Disk	Vert.	Disk	Vert.	Disk	Vert.	Disk	Vert.	Disk	Vert.	Disk
C- 2	..	..	..	..	..	..	..	..	4.4	0.6	..	..	..	..	..	..	..	..	..	..	..	..	..	..
C- 3	..	..	..	..	..	..	8.3	1.0	4.4	0.7	..	..	..	..	..	..	..	..	..	..	..	..	..	..
C- 4	5.5	1.5	..	..	..	..	8.3	1.0	4.4	0.6	..	..	4.6	0.1	..	..	3.9	0.7	5.0	0.4	..	..	..	..
C- 5	6.7	1.3	..	..	..	..	8.3	1.7	4.4	0.6	..	..	7.0	0.4	..	..	3.6	0.5	3.4	0.6	..	..	5.4	1.0
C- 6	6.7	1.3	..	..	3.3	0.5	6.3	1.0	4.6	0.7	..	..	12.7	0.3	..	..	2.9	0.5	3.4	0.7	..	..	5.8	1.0
C- 7	7.0	1.0	..	..	3.3	0.5	4.2	0.7	3.8	0.5	..	..	4.7	0.4	..	..	2.9	0.4	3.0	0.6	4.1	0.5	4.1	1.0
D- 1	5.2	0.8	2.2	0.5	3.0	0.4	3.7	0.8	3.4	0.6	2.6	0.3	2.4	0.3	..	..	3.0	0.3	2.7	0.6	3.1	0.4	3.3	0.7
D- 2	5.6	0.8	2.3	0.3	3.0	0.4	2.4	0.1	3.3	0.6	2.6	0.3	3.6	0.6	..	..	2.5	0.3	2.4	0.4	2.9	0.4	2.5	0.5
D- 3	4.1	0.8	2.2	0.3	2.5	0.3	2.4	0.1	3.0	0.6	2.4	0.3	3.4	0.6	2.1	0.3	1.9	0.2	2.0	0.5	2.6	0.3	2.2	0.5
D- 4	4.0	0.8	2.2	0.3	2.4	0.4	2.5	0.4	2.4	0.5	2.3	0.3	2.1	0.4	1.8	0.2	1.7	0.1	..	..	2.3	0.2	1.6	0.4
D- 5	3.8	0.7	2.2	0.3	2.4	0.4	2.7	0.4	2.4	0.5	2.3	0.3	..	..	1.8	0.2	1.7	0.3	..	..	2.1	0.2	..	..
D- 6	2.9	0.5	2.2	0.3	2.5	0.4	2.7	0.4	2.5	0.5	1.8	0.2	..	..	1.9	0.2	1.9	0.3	..	..	1.9	0.1	..	..
D- 7	3.0	0.5	2.3	0.3	2.5	0.4	2.5	0.4	2.5	0.5	1.7	0.2	..	..	1.6	0.2	1.7	0.3	..	..	1.8	0.2	..	..
D- 8	3.0	0.6	2.3	0.3	2.5	0.4	2.8	0.4	2.5	0.5	1.7	0.2	..	..	1.6	0.2	..	..	..	..	1.8	0.1	..	..

D- 1.....	3.2	0.8	2.2	0.3	3.0	0.4	3.1	0.3	3.4	0.6	2.4	0.3	3.4	0.6	..	..	2.5	0.3	2.4	0.4	2.9	0.4	2.5	0.5
D- 2.....	5.6	0.8	2.3	0.3	3.0	0.4	2.4	0.1	3.3	0.6	2.6	0.3	3.6	0.6	..	..	2.5	0.3	2.4	0.4	2.9	0.4	2.5	0.5
D- 3.....	4.1	0.8	2.2	0.3	2.5	0.3	2.4	0.1	3.0	0.6	2.4	0.3	3.4	0.6	2.1	0.3	1.9	0.2	2.0	0.5	2.6	0.3	2.2	0.5
D- 4.....	4.0	0.8	2.2	0.3	2.4	0.4	2.5	0.4	2.4	0.5	2.3	0.3	2.1	0.4	1.8	0.2	1.7	0.1	..	..	2.3	0.2	1.6	0.4
D- 5.....	3.8	0.7	2.2	0.3	2.4	0.4	2.7	0.4	2.4	0.5	2.3	0.3	..	..	1.8	0.2	1.7	0.3	..	..	2.1	0.2	..	..
D- 6.....	2.9	0.5	2.2	0.3	2.5	0.4	2.7	0.4	2.5	0.5	1.8	0.2	..	..	1.9	0.2	1.9	0.3	..	..	1.9	0.1	..	..
D- 7.....	3.0	0.5	2.3	0.3	2.5	0.4	2.5	0.4	2.5	0.5	1.7	0.2	..	..	1.6	0.2	1.7	0.3	..	..	1.8	0.2	..	..
D- 8.....	3.0	0.6	2.3	0.3	2.5	0.4	2.8	0.4	2.5	0.5	1.7	0.2	..	..	1.6	0.2	..	..	..	..	1.8	0.1	..	..
D- 9.....	2.6	0.4	2.5	0.3	2.5	0.4	2.8	0.4	2.5	0.5	1.6	0.2	..	..	1.7	0.3	..	..	..	..	1.8	0.1	..	..
D-10.....	2.5	0.4	2.3	0.3	2.3	0.4	2.8	0.4	2.2	0.4	1.7	0.2	..	..	1.7	0.3	..	..	..	..	1.8	0.1	..	..
D-11.....	2.6	0.4	2.4	0.3	2.5	0.3	2.4	0.3	2.2	0.4	1.4	0.3	..	..	1.7	0.3	..	..	..	..	1.7	0.1	..	..
D-12.....	2.3	0.3	2.6	0.4	2.5	0.3	2.3	0.3	2.1	0.3	1.4	0.3	1.5	0.1	1.8	0.4	..	..	..	..	1.7	0.1	..	..
L- 1.....	2.4	0.4	2.3	0.3	2.1	0.3	2.2	0.3	2.3	0.4	1.8	0.4	1.5	0.2	1.9	0.5	..	..	..	..	1.9	0.1	..	..
L- 2.....	2.4	0.4	2.3	0.3	2.1	0.3	2.0	0.3	2.1	0.3	1.8	0.4	2.1	0.4	1.9	0.5	..	..	..	..	1.9	0.3	..	..
L- 3.....	2.2	0.4	2.5	0.3	2.2	0.3	2.1	0.2	2.2	0.5	2.0	0.4	2.5	0.6	1.9	0.5	..	..	..	..	1.8	0.3	..	..
L- 4.....	2.2	0.6	2.8	0.4	2.5	0.4	2.4	0.4	1.9	0.6	2.1	0.4	2.5	0.6	2.1	..	..	..	..	..	1.9	0.3	..	..
L- 5.....	2.5	0.5	3.0	0.2	2.3	0.4	3.0	0.5	2.5	0.3	2.9	0.7	2.5	..	2.5	..	..	..	..	..	..	..	..	..
Comment...	.....		.....		Polydactylism				Defect in isthmus between inferior and superior articular facets of L-5; congenital dislocation of hip		Spina bifida occulta of L-5; dyschondroplasia		Spina bifida occulta of C-7; Sprengel's deformity				Bilateral rudimentary cervical ribs of C-7		Bilateral rudimentary cervical ribs of C-7		Bilateral rudimentary cervical ribs of C-7		Bilateral rudimentary cervical ribs of C-7	

Case.....	25		26		27		28		29		30		31		32		33		34		35		36		37	
Age.....	11 Years		11 Years		25 Years		12 Years		10 Years		5 Years		13 Months		5 Years		5 Years		5 Years		6 Years		7 Years		10 Years	
	Vert.	Disk	Vert.	Disk	Vert.	Disk	Vert.	Disk	Vert.	Disk	Vert.	Disk	Vert.	Disk	Vert.	Disk	Vert.	Disk	Vert.	Disk	Vert.	Disk	Vert.	Disk	Vert.	Disk
C- 2.....	..	..	..	..	..	..	..	..	2.5	..	..	..	..	..	..	..	..	..	..	..	4.0	..	..	..	..	..
C- 3.....	..	..	..	..	..	..	..	..	2.5	..	..	..	7.7	..	3.1	0.5	4.7	..	..	..	4.0	..	3.8	0.3	..	..
C- 4.....	..	..	..	..	..	..	2.7	0.6	2.5	..	..	..	11.5	..	3.1	0.4	4.7	..	..	..	7.5	..	2.5	0.3	..	..
C- 5.....	..	..	..	..	2.3	..	2.7	0.6	2.9	..	..	..	7.7	..	3.5	0.4	4.7	..	7.5	0.8	5.0	..	2.8	0.3	..	..
C- 6.....	4.0	0.4	3.7	0.7	2.5	..	2.5	0.5	3.2	..	5.0	0.5	5.0	..	3.5	0.6	4.7	..	6.0	0.8	4.3	..	2.9	0.3	..	..
C- 7.....	3.3	0.4	2.8	0.5	2.5	..	2.4	0.5	3.5	..	4.4	0.4	3.4	..	3.1	..	4.0	..	5.0	0.7	3.8	..	2.7	0.4	..	..
D- 1.....	2.5	0.3	2.5	0.4	2.0	..	2.3	0.4	3.3	..	3.4	0.5	2.7	..	2.2	..	3.5	0.4	5.0	0.8	3.5	..	2.5	0.3	..	..
D- 2.....	2.3	0.3	2.0	0.3	2.1	..	2.1	0.4	3.1	..	2.4	0.3	2.5	..	1.9	..	2.6	0.3	4.1	0.4	2.0	..	2.6	0.4	..	..
D- 3.....	1.8	0.1	1.4	0.2	1.8	..	1.7	0.4	2.0	..	1.6	..	2.3	..	1.5	..	2.3	0.3	2.5	0.2	..	..	1.9	0.3	2.0	0.2
D- 4.....	1.5	0.1	1.3	0.1	1.6	..	1.4	0.3	1.9	..	..	..	2.3	..	1.4	..	2.0	0.3	2.0	..	..	..	1.8	0.3	1.8	0.2
D- 5.....	1.7	0.2	..	..	1.4	..	1.4	0.3	1.7	..	..	..	2.3	..	1.4	..	2.0	0.4	..	..	..	..	1.8	0.3	1.9	0.2
D- 6.....	1.8	0.2	..	..	..	..	1.3	0.3	1.5	..	..	..	1.5	..	1.4	..	1.7	0.3	..	..	..	..	1.5	0.2	1.8	0.2
D- 7.....	1.8	0.2	..	..	..	..	1.4	0.3	1.6	..	..	..	..	..	1.4	..	1.5	0.2	..	..	..	..	1.4	0.3	1.6	0.2
D- 8.....	1.6	0.2	..	..	..	..	1.4	0.3	1.6	..	..	..	..	..	..	..	1.5	0.2	..	..	..	..	1.4	0.3	1.6	0.2
D- 9.....	1.6	0.2	..	..	..	..	..	..	1.5	..	..	..	..	..	..	..	1.6	0.2	..	..	..	..	1.6	0.3	1.6	0.2
D-10.....	..	..	..	..	..	..	..	..	1.6	..	..	..	..	..	..	..	1.5	0.2	..	..	..	..	1.7	0.3	1.6	0.2
D-11.....	..	..	..	..	..	..	..	..	1.7	..	..	..	..	..	..	..	1.5	0.3	..	..	..	..	1.7	0.3	1.7	0.3
D-12.....	..	..	..	..	..	..	..	..	1.7	..	..	..	..	..	..	..	1.6	0.3	..	..	..	..	1.8	0.4	1.8	0.3
L- 1.....	..	..	..	..	..	..	..	..	1.6	..	..	..	..	..	..	..	1.4	0.2	..	..	..	..	1.8	0.4	2.0	0.4
L- 2.....	..	..	..	..	..	..	..	..	1.6	..	..	..	..	..	..	..	1.4	0.3	..	..	..	..	1.8	0.5	2.8	0.4
L- 3.....	..	..	..	..	..	..	..	..	1.7	..	..	..	..	..	..	..	1.6	0.3	..	..	..	..	2.0	0.5	2.2	0.4
L- 4.....	..	..	..	..	..	..	..	..	1.9	..	..	..	..	..	..	..	1.6	0.3	..	..	..	..	2.2	0.4	2.3	0.4
L- 5.....	..	..	..	..	..	..	..	..	2.2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0.4	2.7	..
Comment	Bilateral rudimentary cervical ribs of C-7		Bilateral rudimentary cervical ribs of C-7		Hypertrophy of transverse processes of C-6 and 7		Hypertrophy of transverse processes of C-7		Bilateral rudimentary cervical ribs of C-7		Bilateral rudimentary cervical ribs of C-7; Sprengel's deformity		Congenital flexion deformity of thumb		Bilateral rudimentary cervical ribs of C-7				Sprengel's deformity		Congenital torticollis; hypertrophied transverse processes of C-7; defect in fusion between lateral masses centra of C-5 and C-6		Congenital talipes		Defect in isthmus between superior and inferior articular facets of L-5	

* Vert. refers to the vertebral bodies, and disk, to the intervertebral disks.

Measurements on the roentgenographic films revealed that the ratios of the transverse diameters to the vertical diameters of the lumbar vertebrae were higher than the normal values. It is therefore evident that the fourth and fifth lumbar vertebrae were definitely disproportioned, while the intervertebral disks were within normal range. (Compare table 5 with table 2.)

CASE 2.—E. S., a white boy 5 years of age, had been in the service of Dr. Leo Mayer for a tuberculous infection of the hip. The roentgenographic picture shown here was made incidentally, and has no relationship to the patient's complaint.

The anteroposterior roentgenographic view (fig. 2) showed that the fourth and fifth lumbar vertebrae were increased in their transverse diameters, while their vertical diameters were markedly diminished. The intervertebral disk below

Fig. 2 (case 2).—Platyspondyly, type 1. The transverse diameters of the fourth and fifth lumbar vertebrae are increased, while their vertical diameters are diminished. The height of the fourth intervertebral disk is greater than normal. Compare with figure 3.

the fourth lumbar vertebra showed a corresponding increase in its vertical diameter. The extent of this disproportion is shown in table 5, which is to be compared with the normal values in tables 2 and 4.

Figure 3, an anteroposterior roentgenogram of a 5 year old child demonstrates visually the appearance of the fourth and fifth lumbar vertebrae and their subjacent disks under normal conditions.

CASE 3.—M. S., a 5 year old boy, was admitted to the Hospital for Joint Diseases because of acute osteomyelitis of the upper end of the femur.

The anteroposterior roentgenogram (fig. 4) revealed that the fifth lumbar vertebra was diminished in height and increased in width, while the subjacent

Fig. 3.—Visual demonstration of the normal proportions of vertebral bodies and intervertebral disks in a 5 year old child for comparison with figures 2, 4 and 5.

Fig. 4 (case 3).—Platyspondyly, type 1. The transverse diameter of the fifth lumbar vertebra is increased, and its vertical diameter is diminished. The subjacent intervertebral disk is abnormally high. Compare with figure 3.

intervertebral disk showed a corresponding increase in its vertical diameter. The upper sacral segments presented spina bifida occulta. Table 5 shows the increased ratios of the vertebrae and their intervertebral disks. A comparison of the spine in figure 4 with the normal spine shown in figure 3 will definitely establish the disproportion noted in this case.

CASE 4.—G. H., a 6 year old white boy, was admitted to the outpatient department of the Hospital for Joint Diseases because of pain in the region of the left hip joint.

Physical examination gave negative results, save for a slight limitation of internal rotation of the left thigh.

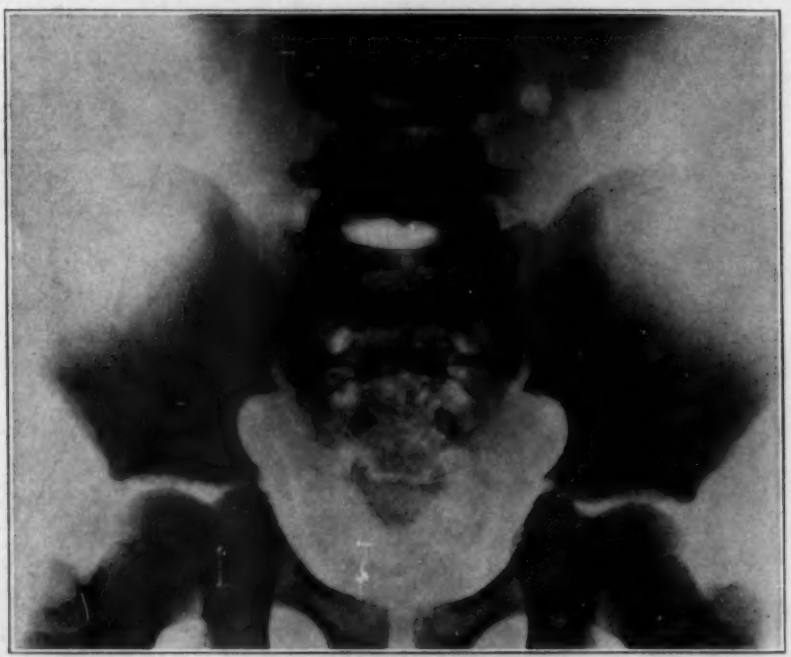

Fig. 5 (case 4).—Platyspondyly, type 1. The fifth lumbar vertebra is widened transversely and narrowed vertically. The intervertebral disks above and below are increased in their vertical diameters. Compare with figure 3.

Roentgenographic examination (fig. 5) revealed an irregularity and rarefaction at the left ischiopubic juncture. As an incidental finding it was noted that the fifth lumbar vertebra was widened transversely and narrowed vertically. The intervertebral disks above and below this segment were increased in their vertical diameters. (Compare table 5 with tables 2 and 4).

CASE 5.—D. O'B., a 12 year old white girl, was admitted to the service of Dr. Samuel Kleinberg, at the Hospital for Joint Diseases, because of a slipping of the epiphysis of the upper part of the right femur and Legg-Perthes' disease of the left hip. There was no history or physical findings referable to the back.

The following findings were discovered incidentally on roentgenographic examination (fig. 6): The fifth lumbar vertebra was markedly widened trans-

versely and narrowed vertically. The intervertebral disk between the fifth lumbar segment and the sacrum was increased in its vertical dimension. (Compare table 5 with tables 2 and 4.) It was also noted that the posterior arch was not fused. The same was true of the first sacral segment.

Comment.—Cases 1 to 5, inclusive, are instances of platyspondyly of type 1 described by Putti. In all of them the roentgenographic appearances were typical; that is, there was an increase in the transverse diameters and a decrease in the vertical diameters of the lower lumbar vertebrae, most commonly the fourth and fifth. This was accom-

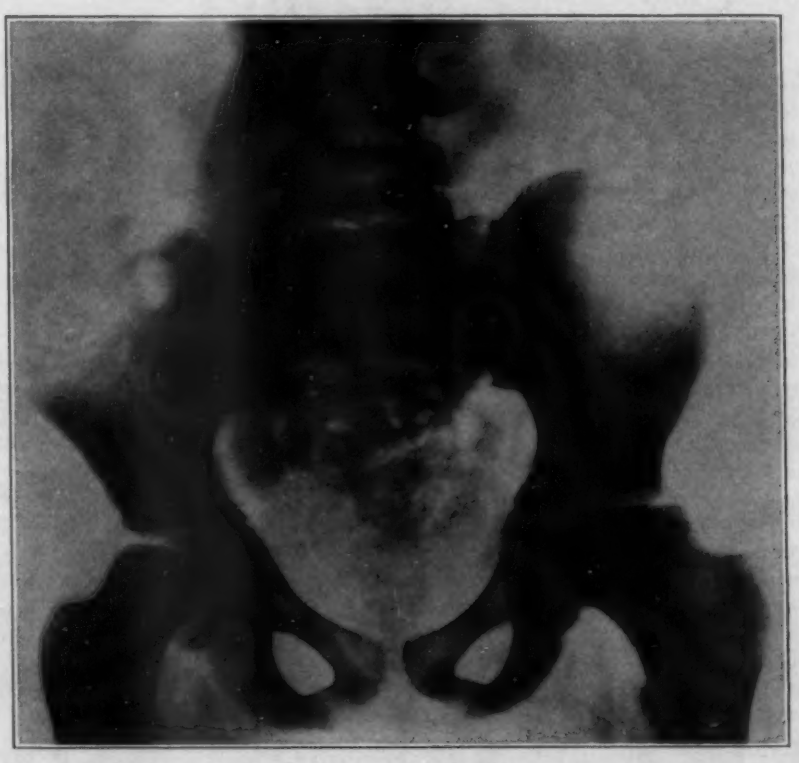

Fig. 6 (case 5).—Platyspondyly, type 1. The fifth lumbar vertebra is markedly widened transversely and narrowed vertically. The subjacent disk is increased in its vertical diameter.

panied in some of the instances by an increase in the vertical diameters of the intervertebral disks. These changes resulted in increased ratios, which are shown in table 5. A comparison of these abnormal ratios with the normal values shown in tables 2 and 4 reveals the extent of these variations, which were greatest in case 4. In this instance the ratios for the fourth and fifth lumbar vertebrae are 3.3 and 3.4, while the normal values for the same age group are only 1.9 and 1.9,

respectively. A relative increase in the ratios of their subjacent intervertebral disks is also present, 0.7 and 0.7, which are to be compared with the normal values, 0.5 and 0.4.

Figure 3, a normal roentgenogram of a 5 year old child, is presented to give a visual comparison between the type of spine under discussion and the normal spine.

It is also to be noted that in three of these cases there were other evidences of the congenital anomalies—spina bifida occulta of one or more vertebrae. Clinically, the patients presented asymptomatic pictures.

CASES OF TYPE 2

CASE 6.—F. DeJ., a 5 year old girl, was admitted to the first orthopedic division of the Hospital for the Ruptured and Crippled on March 11, 1927, because it had been noted that ever since birth she had been unable to turn her head. Her chin had been getting progressively closer to the chest, which was becoming more and more prominent. She had, in addition, occasional pains in the back and limbs. Notwithstanding all the deficiencies that the child had, she had been very active.

Physical examination revealed that the child was in good general condition and presented a typical appearance of Pott's disease, as evidenced by the angular curve in the upper part of the dorsal region and shortened trunk. The chin was habitually depressed on the chest.

The roentgenographic examination revealed a congenital malformation of the spine and ribs, the details of which were difficult to interpret. The anteroposterior view (fig. 7 *A*) revealed that in the lower part of the cervical region the segments were abnormally widened and thinned. In the upper part of the dorsal region there was a group of ill defined segments which were wedge shaped and partially fused into one mass. The lower dorsal and the first lumbar segments presented clear instances of somatoschisis and spina bifida. All of these segments, especially the first lumbar and lower cervical, were diminished in their vertical diameters and increased in their transverse diameters. The intervertebral disks, although not widened, dipped into the hiatuses formed by the hemivertebrae. The fifth lumbar segment was definitely widened transversely and narrowed in its vertical diameter. The sacral segments presented spina bifida anomalies. In addition, it was noted that there were apparently only ten dorsal segments. The ribs presented extensive anomalies of morphology and number. The lateral view (fig. 7 *B*) showed an irregular fusion of the upper dorsal segment. The tenth dorsal segment was markedly narrowed in its vertical diameter. There was also a failure of fusion of the centra with the posterior arches in the mid-dorsal region. The vertical diameters of the intervertebral disks were markedly irregular. The fifth lumbar vertebra was narrowed in its vertical diameter, and its adjoining disks were correspondingly increased in height.

Measurements of the various diameters to obtain the necessary ratios were not made because of the inaccuracies that would result from the marked irregularities in shape and wedging of the vertebral segments. The roentgenographic appearances are, however, so definite that one can readily appreciate the generalized increase in the ratios of the transverse to the vertical diameters of the vertebrae and the increased height of some of the intervertebral disks.

CASE 7.—S. G., a boy aged 10 months, was seen in the outpatient department of the Hospital for Joint Diseases because of a congenital torticollis on the right side.

Roentgenographic study (fig. 8) revealed that the cervical region and the three upper dorsal vertebrae were markedly thinned in their vertical diameters and widened transversely. The fifth, sixth and seventh cervical segments presented somatoschisis with an overlapping of the lateral halves of the vertebral bodies. The third and fourth cervical and the first, second and third dorsal vertebrae, although widened, presented no defects of fusion. The intervertebral disks in the entire region were proportionately increased in their vertical diameters. In addition, there was a cervical rib on the right side.

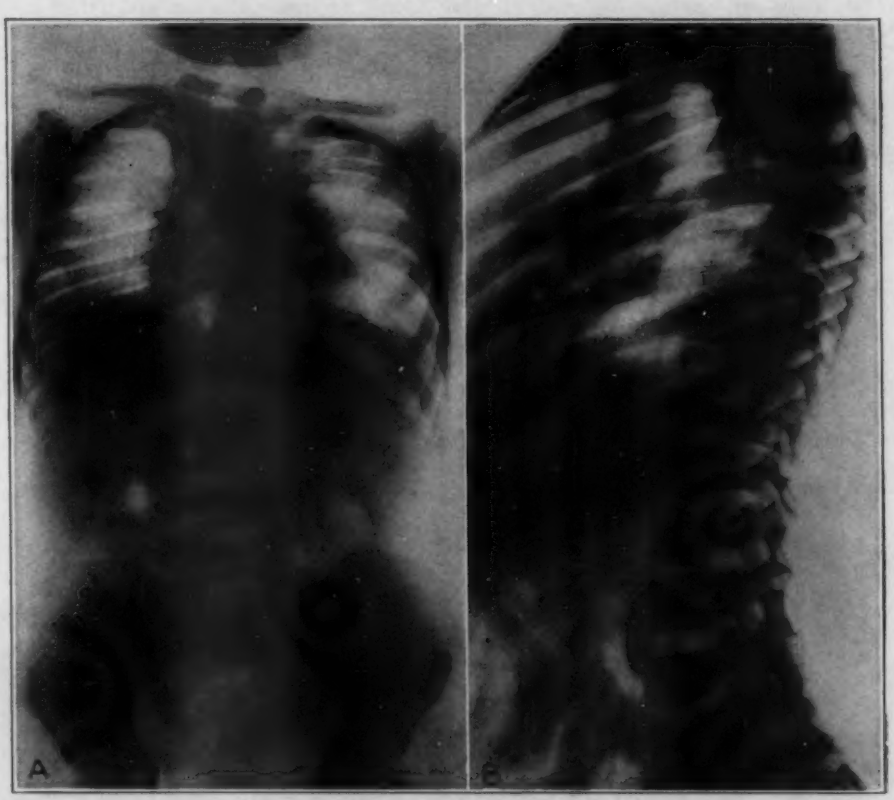

Fig. 7 (case 6).—Platyspondyly, type 2. In *A*, multiple congenital anomalies are pictured. The cervical vertebral segments are abnormally widened and thinned. In the upper dorsal regions there are a group of ill defined, wedge-shaped segments partially fused into one mass. The lower dorsal and first lumbar segments present somatoschisis, spina bifida, increased transverse diameters and diminished vertical diameters. The fifth lumbar segment is definitely widened transversely and narrowed vertically. In *B* the tenth dorsal segment is markedly thinned in its vertical axis. There is a failure of fusion of the centra with the posterior arches in the mid-dorsal region. The fifth lumbar segment is narrowed vertically.

Measurements revealed a marked increase in the ratios of the transverse to the vertical diameters of the vertebrae, as is shown by table 5, in comparison with the normal values in table 2. Corresponding measurements showed the increase in the vertical diameters of the adjoining intervertebral disks (tables 4 and 5).

Case 8.—P. A., a white boy aged 14, was admitted to the outpatient department of the Hospital for Joint Diseases because of a congenital right cervical scoliosis.

The roentgenogram (fig. 9) revealed extensive congenital changes in the cervicodorsal region in addition to the deviation of the spine to the right. The vertebrae of the lower part of the cervical and the upper part of the dorsal region were enlarged transversely and thinned vertically, the sixth and seventh cervical and the first dorsal vertebrae being most markedly affected. Along the midline of the bodies of these vertebrae there were apexes on their superior and inferior surfaces. The fourth cervical vertebra was approximately normal in width and height. In the upper part of the dorsal region several of the vertebral segments were fused into a wedge-shaped mass. (See table 5 for ratios of measurements.)

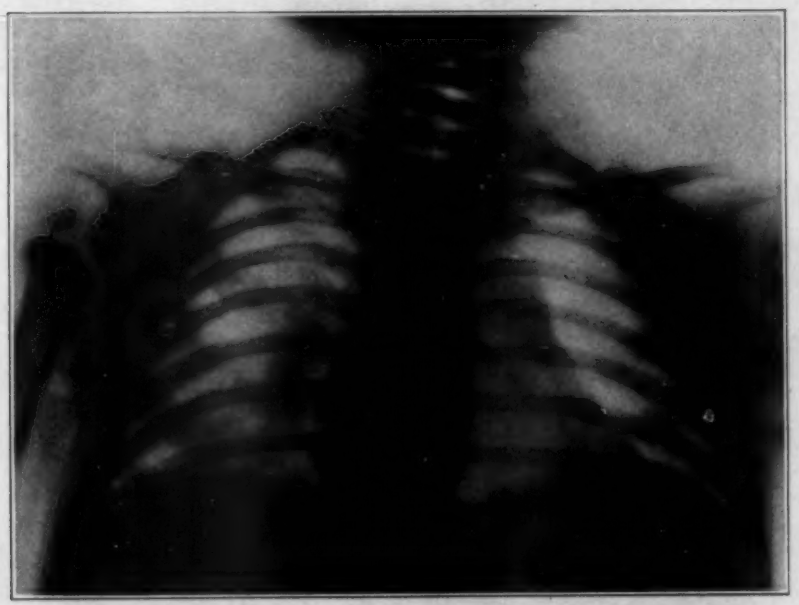

Fig. 8 (case 7).—Platyspondyly, type 2. The vertebral segments of the cervical and upper dorsal region are markedly widened transversely and thinned vertically. There is somatoschisis with overlapping of the lateral halves of the fifth, sixth and seventh cervical vertebrae. The intervertebral disks are disproportionately increased in their vertical diameters. See table 5 and compare with tables 2 and 4.

Case 9.—The history and results of the physical examination of the patient (J. M.) were not available. A roentgenogram (fig. 10) revealed extensive platyspondyly involving the cervical and the upper part of the dorsal region. There was in addition, a hemivertebra between the sixth and the seventh cervical segments, and Sprengel's deformity bilaterally. Table 5 shows the disproportion of the transverse to the vertical diameters, expressed in numerical ratios. These values are to be compared with the normal ratios in table 2.

Case 10.—No record of this case is available save for the roentgenograms (fig. 11), which showed an extensive narrowing of the vertical diameters and widening of the transverse diameters, most marked in the cervical region. This

disproportion was also evident in the dorsal region but to a lesser degree. Spina bifida occulta of the sixth, seventh and eighth dorsal segments was also noted. The tenth dorsal vertebra presented somatoschisis. In addition, there were cervical ribs bilaterally, while the seventh rib was markedly thinned. (Compare table 5 with the normal in table 2).

CASE 11.—M. B., a white youth aged 18, was admitted to the outpatient department of the Hospital for Joint Diseases complaining of a curvature of the spine of five years' duration. He gave no history of pain or injury to his back.

Fig. 9 (case 8).—Platyspondyly, type 2. The lower cervical and first dorsal segments are enlarged transversely and narrowed vertically. Note the apexes on the superior and inferior surfaces of these vertebrae.

Clinical examination gave essentially negative results save for the local findings. There was kyphosis at the level of the upper part of the lumbar region, with a loss of the normal lumbar hollow. All motions with the exception of that at the lumbosacral articulation were obliterated. No tenderness could be elicited.

Roentgenographic examination revealed (fig. 12 *A*) a gradual increase of the transverse diameters of the vertebral segments from above downward, reaching

its maximum at the fifth lumbar vertebra. The fourth and more so the fifth segment were narrowed vertically. The intervertebral disk between the fourth and the fifth lumbar vertebra was considerably greater in its vertical diameter than those above it. (Compare table 5 with table 2.) The upper sacral segment presented a failure of fusion of its posterior arch. A lateral roentgenographic view of the spine revealed (fig. 12 *B*) bony fusion of the anterior halves of all of the vertebrae from the twelfth dorsal vertebra down to and including the fourth lumbar vertebra, with obliteration of the anterior halves of the intervertebral spaces. There were irregularities of the outlines and calcification of the upper aspect of the fourth lumbar and the anterior portions of the superior and inferior surfaces of the lower dorsal vertebrae. The latter changes were suggestive of herniations of the nucleus pulposus.

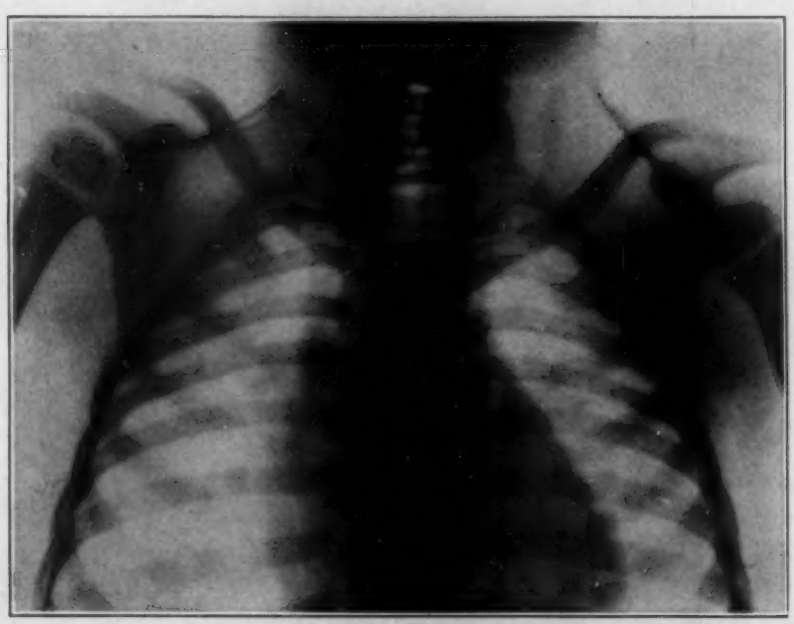

Fig. 10 (case 9).—Platyspondyly, type 2. The transverse diameters of the cervical and upper dorsal regions are increased and the vertical diameters are decreased. Note the hemivertebra between the sixth and the seventh cervical vertebra and Sprengel's anomaly bilaterally.

Case 12.—M. C., a 5 year old girl, was admitted to the service of Dr. Finkelstein at the Hospital for Joint Diseases because of torticollis, said to be of six months' duration, resulting from mumps.

Roentgenographic examination revealed (fig. 13) an increase in the transverse diameters and a diminution in the vertical diameters of all of the cervical vertebrae. There was an associated increase of the vertical diameters of the adjacent intervertebral disks. (Compare table 5 with tables 2 and 4.) The fifth cervical body consisted of two wedges with their apexes toward the center and presented a definite somatoschisis. The transverse processes of the seventh cervical vertebra were somewhat enlarged. In view of all of these congenital anomalies the torticol-

lis may have been congenital in origin rather than acquired, for the deformity may have passed unnoticed, and the mumps may have merely focused the parents' attention on this distortion.

Comment.—Cases 6 to 12, inclusive, are instances of type 2 of platyspondyly described by Lance. This is the group of cases that are

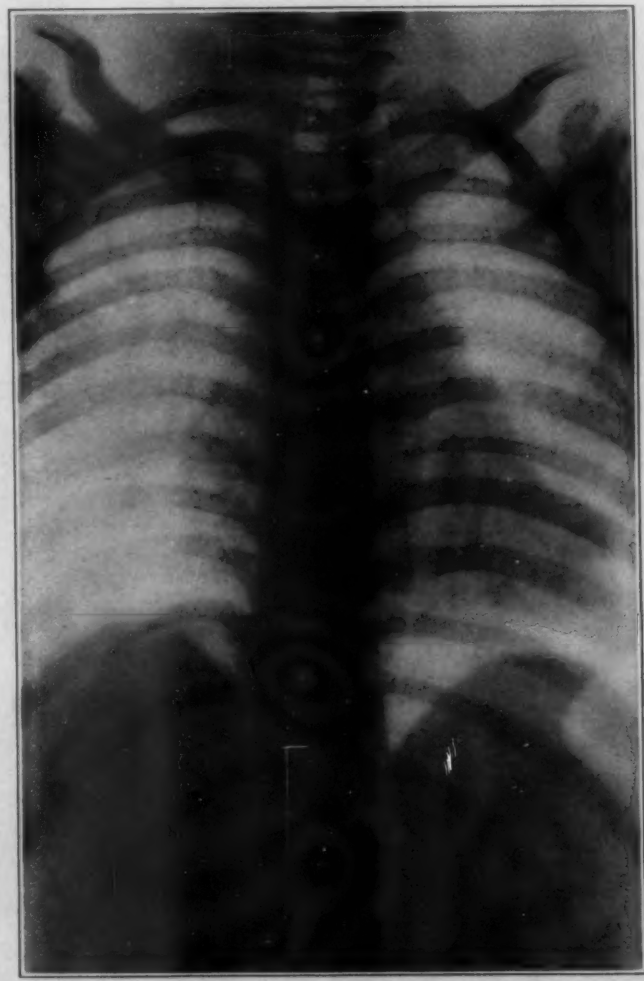

Fig. 11 (case 10).—Platyspondyly, type 2. The vertical diameters of the cervical region are extensively narrowed and the transverse diameters are widened. There is a less evident disproportion in the dorsal region.

characterized by extensive anomalies in morphology, such as platyspondyly, wedge-shaped vertebrae, hemivertebrae, a defect in the isthmus between the superior and the inferior articular facet and the Klippel-Feil syndrome; by anomalies in numerical variations such as

occipitalization of the first cervical vertebra, dorsalization of the seventh cervical vertebra (as expressed by the presence of cervical ribs), dorsalization of the first lumbar vertebra (presence of ribs on the first lumbar vertebra), lumbarization of the first sacral vertebra and sacralization of the fifth lumbar vertebra, and finally anomalies by suppression, such as spina bifida, somatoschisis or the failure of developments

Fig. 12 (case 11).—Platyspondyly, type 2. In *A*, the transverse diameters gradually increase from above downward, the maximum size being at the fifth lumbar vertebra. The fourth and especially the fifth segments are narrowed vertically. The fourth disk is increased in height. In *B*, the anterior halves of vertebral bodies are fused with obliteration of the vertebral disks.

of ossification centers. In the cases here described the platyspondylitic changes noted were associated, depending on the instance, by one or more of the foregoing variations. All of these variations occur at approximately the same period of embryologic development. The

platyspondylitic deformities are of little significance when contrasted with the other extensive congenital anomalies. Nevertheless, they are of theoretical importance in the visualization of the development of the various groups of platyspondyly. Clinically, the symptoms, if any are present, are due to the associated changes in the bony or soft tissue.

CASES OF TYPE 3, GENERALIZED FORM

CASE 13.—S. C., a 3½ year old girl, American born, of Jewish extraction, was admitted to the pediatric service of Dr. Sobel at the Hospital for Joint Diseases because of retarded development. The child apparently had a normal birth, and

Fig. 13 (case 12).—Platyspondyly, type 2. The transverse diameters are increased and the vertical diameters are diminished throughout the cervical region. There is an associated increase in thickness of the disks and somatoschisis of the fifth cervical segment.

no untoward symptoms were noted until she was 5½ months of age, when she began to cry frequently and have frequent sweating of the head. Her skin began to take a yellowish hue, and she became subject to fainting attacks, which recurred up to several months before her admission to the hospital. Occasionally there occurred a sudden pallor of the finger tips, which would disappear in a few minutes. About a month previous to admission to the hospital, treatment with cod liver oil and thyroid was instituted, and as a result the symptoms improved.

At 3 months of age the patient held her head up; at 2½ years of age she sat up, and at 3 years and 4 months of age she was able to stand with support. Her first teeth appeared at the twenty-second month, and on admission she did not either walk or talk, while her tongue lolled and her mouth drooled.

Physical examination revealed a dull child. She held her head weakly, and in the sitting posture (fig. 14 *A*) presented a marked curve of weakness, bracing herself with one or both hands. She could stand only when her hands were held and in doing so presented evidences of weakness, as indicated by dependence on the supporting hands, hyperextended back, flexed hips and hyperextended knees (fig. 14 *B*). She was unable to walk.

Her facies was typically myxedematous; the eyes were narrow and widely spread; the tongue lolled, and the mouth drooled. The skin was dry and cold.

Fig. 14 (case 13).—Platyspondyly, type 3, generalized form. In *A*, a marked curve due to weakness of the back is pictured. Note the bracing with the left hand. In *B*, there is marked weakness of the back in the standing position. Note the dependence on the supporting hands of the attendant, hyperextended back, flexed hips and hyperextended knees. The patient was unable to stand alone or walk at 3½ years of age.

The hair was coarse and sparse, while the scalp presented small dry yellowish scales. The eyelids were puffy, and the eyes presented an internal strabismus and fine rotatory nystagmus bilaterally. The teeth were small, widely separated and poorly developed. The pharynx was narrow and the palate had a high arch. The abdomen presented a large umbilical hernia. The back was symmetrical, and the spine was in the midline. There were no lateral deviations, and the normal antero-posterior curves were not developed, while the long posterior curve of infancy was still persistent. The spine was abnormally flexible in all directions.

The anteroposterior roentgenogram showed (fig. 15) a mild total curvature of the spine to the left. All of the vertebrae were definitely thinned in their vertical diameters and widened in their transverse diameters. This was most marked in the cervical region. The superior and inferior borders of each of these vertebrae presented a concave contour, with the apex of the concavities approximating each other in the center. Beginning with the first dorsal segment and extending down to and including the eleventh dorsal segment there was spina

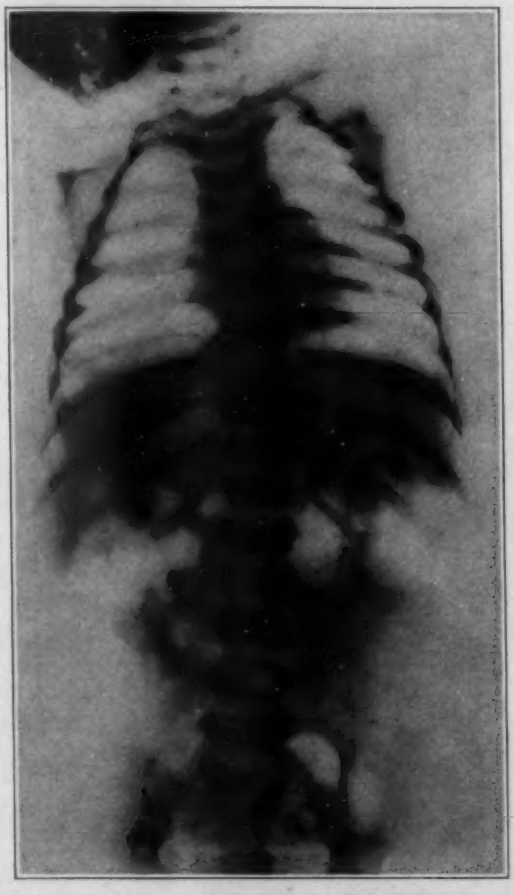

Fig. 15 (case 13).—Most characteristic generalized platyspondyly. There is widening of the transverse and diminution of the vertical diameters throughout the spine, especially in the cervical region. The superior and inferior surfaces present concavities, the apexes of which approximate each other in the midline, indicating the plane of incomplete fusion of the lateral halves of the vertebra in the membranous stage of development. The intervertebral disks are disproportionately enlarged vertically. Compare with figure 17.

bifida occulta, as was evidenced by the failure of fusion of the posterior arches. In the center of each vertebra there were two perforations, most marked in the lumbodorsal and in the upper part of the lumbar regions. These were evidently the

points of entry of the blood vessels to these segments. The intervertebral spaces were abnormally enlarged in their vertical diameters. Their superior and inferior borders were convex and corresponded with the concavities in the vertebral bodies.

The lateral roentgenogram (fig. 16) showed a total posterior curve with its apex at the second lumbar vertebra. There were marked irregularities in the anterior margins of all of the spinal segments, most marked in the midlumbar region. There were incisurae in these borders corresponding to the perforations noted in the anteroposterior view. The anteroposterior dimensions of the lumbar vertebrae varied considerably.

Fig. 16 (case 13).—There is absence of the normal anteroposterior curves. The intervertebral disks are disproportionately high. Note the incisurae, the points of entrance of intersegmental arteries indicating the plane of fusion of the caudal and cranial halves of adjoining sclerotomes to form the primitive vertebra in the membranous stage of development.

Roentgenographic examinations of the extremities showed little save for transverse lines of calcification in the metaphyses of the lower part of the femur and the upper part of the tibia and slight thickening of the cortices. The epiphysial plates of the lower part of the tibia instead of being transverse were irregular, in that the one on the left side ran obliquely upward and inward, while that on the right side ran obliquely inward and downward and then upward and inward. The carpi presented only two small centers of ossification, while the tarsi presented but four centers of ossification.

Measurements revealed that the ratios of the transverse to the vertical diameters of the various vertebrae showed a marked increase, ranging up to 7.0 for the seventh cervical vertebra, whereas the average normal for this age is only 2.3. The lowest ratio was 2.2 for third and fourth lumbar vertebrae, in contrast to the normal, 1.9. (Compare table 5 with table 2.) Corresponding measurements revealed a marked increase in the ratios of the vertical diameter of the intervertebral disks to the vertical diameters of the vertebrae. These varied from a maximum of 1.5 for the fourth cervical vertebra to 0.3 for the twelfth dorsal vertebra, the latter being the only figure within normal range. (Compare table 5 with table 4.)

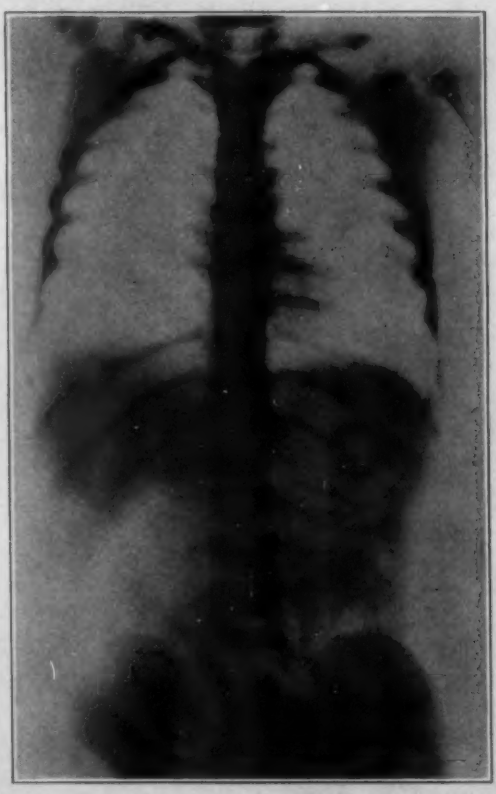

Fig. 17.—A roentgenogram of a 3½ year old child showing the normal relationship between the transverse and the vertical diameters of the vertebral segments and their relationship to the height of the subjacent disks. Compare with figure 16.

Figure 17, a roentgenogram of a 3½ year old child, shows the normal relationship between the transverse and the vertical diameters of the various vertebrae. It also demonstrates graphically the normal relationship of the height of the intervertebral disks to the height of the superjacent vertebra.

Case 14.—R. M., a 20 month old white boy, was admitted to the pediatric service of Dr. Sobel at the Hospital for Joint Diseases because of severe anemia and symptoms referable to the gastro-intestinal tract secondary to chronic lead poisoning.

Physical examination gave essentially negative results, save for evidences of anemia and poor nourishment. Examination of the blood revealed severe secondary anemia.

The anteroposterior roentgenogram of the spine (fig. 18 *A*) showed that the cervical and the first dorsal vertebrae were wider transversally than those in the upper third of the dorsal region. From this area down to and including the fifth lumbar vertebra there was a progressive widening of the vertebral bodies, reaching its maximum in the fifth lumbar segment. The normal ratio of height to width

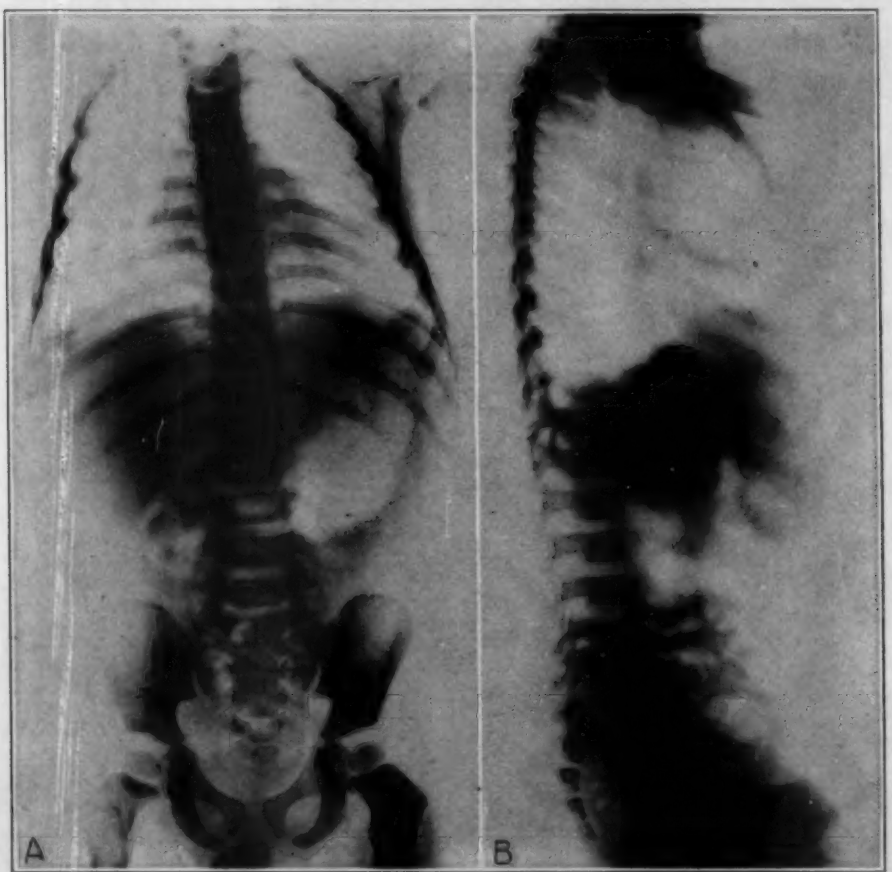

Fig. 18 (case 14).—Platyspondyly type 3, generalized form. In *A*, the defect is most marked in the lower lumbar region. In *B*, the vertical diameters of the intervertebral disks are increased, especially in the lower lumbar region.

of the bodies became increasingly disturbed from above downward, reaching its most marked disproportion in the fifth lumbar segment. Some of the vertebrae showed, mildly, the characteristic concavities on the superior and inferior surfaces. The vertical diameter of the intervertebral disks also became progressively increased toward the base of the spine. This was more clearly demonstrated in the lateral view (fig. 18 *B*).

Measurements resulted in ratios for the vertebral bodies that were higher than normal, especially for the lumbar region. The entire spine was, however, involved. The ratios for the intervertebral disks showed but a slight deviation from the normal. (Compare table 5 with tables 2 and 4).

CASE 15.—K. K., a 2 year old Negress, was admitted to the service of Dr. Kleinberg at the Hospital for Joint Diseases because of polydactylism of both hands and feet.

The results of the physical examination were essentially negative, save for the bilateral supernumerary fingers and toes.

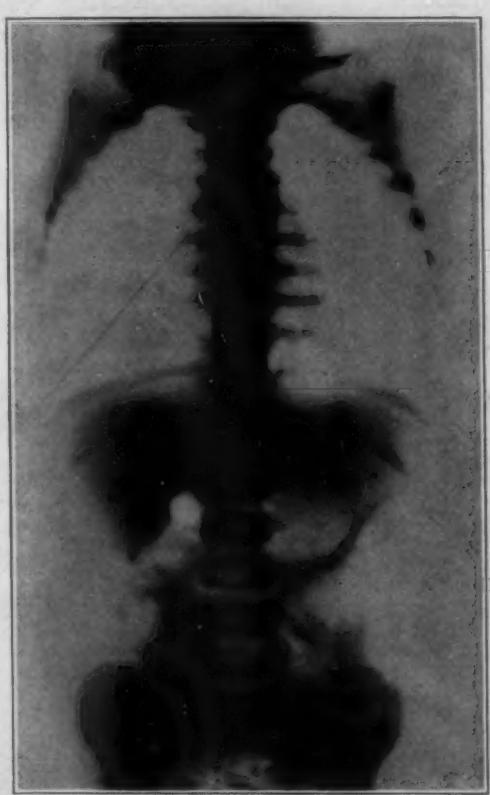

Fig. 19 (case 15).—Generalized platyspondyly, most marked in the upper and lower ends of the spine. Note the increased transverse and disproportionately small vertical diameters of the vertebral segments. The height of the intervertebral disks is increased.

A roentgenographic study was made in search of a possible platyspondyly (fig. 19). Save for the mid-dorsal region, there was a tapering increase, extending caudad and cephalad of the transverse diameters, and a decrease in the vertical diameters of all of the vertebral segments. The vertebral segments at the upper and the lower end of the spine were most involved. The foregoing changes were accompanied by increased thickness of the intervertebral disks.

Measurements revealed ratios that were more graphic in the demonstration of the disproportion between the transverse and the vertical diameters of the vertebral bodies of the entire spine. (Compare table 5 with table 4.) The measurements of the intervertebral disks showed some increase in the ratios, but only in the upper portion of the spine.

Case 16.—J. T., a 1 year old girl, was admitted to the pediatric service of Dr. Sobel for observation for a possible tuberculous lesion of the lungs and secondary anemia. There was no history or physical findings referable to the spine.

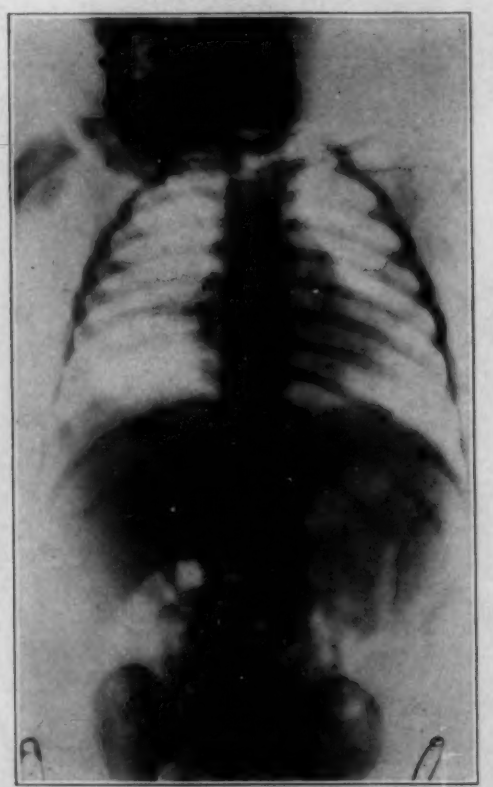

Fig. 20 (case 16).—Generalized platyspondyly, most marked in cervical and lower lumbar regions.

Roentgenographic examination revealed (fig. 20) that the transverse diameters of the entire spine but more especially in the cervical region were markedly increased. The heights of these vertebrae were decreased, while those of the intervertebral disks were increased. (Compare table 5 with tables 2 and 4.)

Case 17.—L. M., an 18 month old white girl, was admitted to the service of Dr. Samuel Kleinberg at the Hospital for Joint Diseases because of unilateral congenital dislocation of the hip. Roentgenograms were made of the entire spine with the idea that there might possibly be additional congenital anomalies in the form of platyspondyly. Generalized platyspondyly, type 3, and a congenital defect in the isthmus between the superior and the inferior articular facet of the fifth

lumbar vertebra were found. The latter anomaly was recently reported by Dr. Kleinberg in an article on prespondylolisthesis as occurring in the youngest patient whose case is on record.

The immediate interest in this case was aroused by a roentgenogram (fig. 21), which revealed a widening of the transverse and a diminution of the vertical diameters of all vertebrae, most marked in the upper portion of the spine. The dorsal vertebrae showed, in a measure, the typical concavities of the superior and inferior surfaces. The intervertebral disks were increased in their vertical diameters, and in the dorsal region they presented the characteristic convexities on their superior and inferior surfaces. (Compare table 5 with tables 2 and 4.)

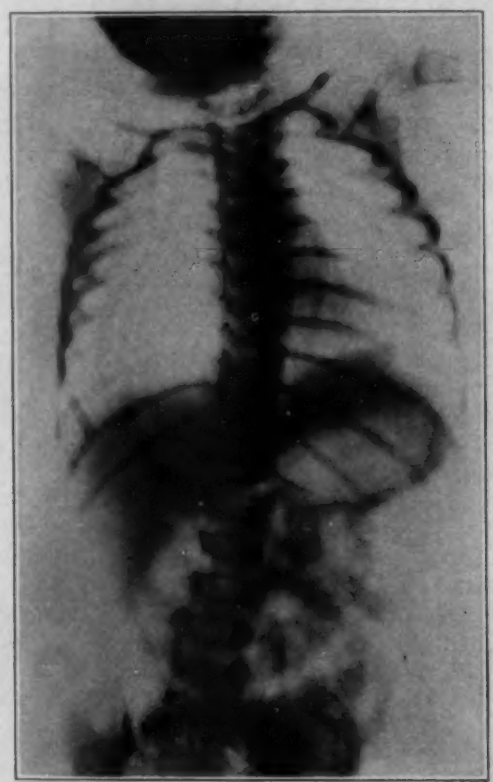

Fig. 21 (case 17).—Generalized platyspondyly. Note the typical concavities on the superior and inferior surfaces of the mid-dorsal segments.

Comment.—Cases 13 to 17, inclusive, are instances of the generalized form of platyspondyly type 3. This form is rare, for only six cases have been heretofore described. This type is the only one that may possibly give rise to clinical symptoms and findings. I have had the opportunity to examine clinically only three patients with this type (cases 13, 15 and 17). The other cases were culled from the roentgenographic files. Clinical examination in these cases would have been inconclusive, for in patients of those ages, 1 year and 20 months, any

weakness of the spine would in all probability be referred to the physiologic weakness of infancy. In case 17 the anomaly was discovered only after the hip had been reduced and immobilized in plaster of paris. Furthermore, any findings would have been inconclusive because of the patient's age and the complicating effects of the dislocation. In case 14 there were no physical findings referable to the spine. This, however, may be accounted for by the rather mild platyspondylitic anomaly. Case 13, however, was ideal, and the findings in this instance were typical and corresponded closely to those described by Lance and others. The outstanding feature was marked weakness of the back and absence of the normal anteroposterior curves.

Roentgenographically, these cases were readily recognized, as is evident by comparing the normal appearance in figure 17 with that of any of the abnormal appearances shown in figures 15, 18 *A*, 19, 20 and 21. Measurements differentiate the normal from the abnormal, as shown in tables 5, 2 and 4.

CASES OF TYPE 3, LOCALIZED FORM

CASE 18.—J. T., a 6 year old white boy, was admitted to the service of Dr. Kleinberg at the Hospital for Joint Diseases for removal of several exostoses incidental to an extensive chondrodysplasia. The patient's father and brother have similar disturbances.

The details of the physical examination are omitted as they are irrelevant to the discussion, save that a marked shortening of both upper and lower extremities with many exostoses and widening of metaphyses was noted.

The spine was normal clinically and roentgenographically, save for the incidental finding of platyspondyly of the third, fourth and fifth lumbar vertebrae, which was most marked in the fifth, as shown in figure 22. The last lumbar segment was much narrower in its vertical diameter and wider in its transverse diameter than the vertebra above it. There was also a similar disturbance in the upper part of the dorsal region but to a less marked degree. The subjacent intervertebral disk of the fifth lumbar vertebra was increased in height when compared with those above it. There was, in addition, a failure of fusion of the posterior arch of the fifth lumbar segment.

Measurements yielded the various ratios, as shown in table 5, and comparisons with the average normal values, to be found in tables 2 and 4, reveal the disturbance very distinctly.

This case demonstrates that no hard and set rules may be laid down in the classification of the various types. Because of the involvement of the lower part of the lumbar region, one may classify this as an instance of type 1. In this instance, as in several subsequent cases to be reported, there were two areas involved, that is, the upper part of the dorsal region and the lower part of the lumbar region. It is because of this multiplicity of the lesion that it has been classified as type 3, localized form.

CASE 19.—J. F., a 6½ year old white boy, was admitted to the outpatient department of the Hospital for Joint Diseases with the chief complaint of round shoulders. The past history of the patient is irrelevant.

Physical examination revealed that the child was in good general condition. It was noted that the neck was abnormally short and wide and that the hair line was unusually low. The right shoulder was narrower than the left, and the right scapula was higher than the left. Rotation of the neck to the left was possible only to 35 degrees; rotation to the right was limited at 45 degrees. Flexion of the neck was only one half of the normal range, while extension and hyperextension were normal. The back was normal clinically save for a moderate increase in the posterior curve of the spine in the dorsal region.

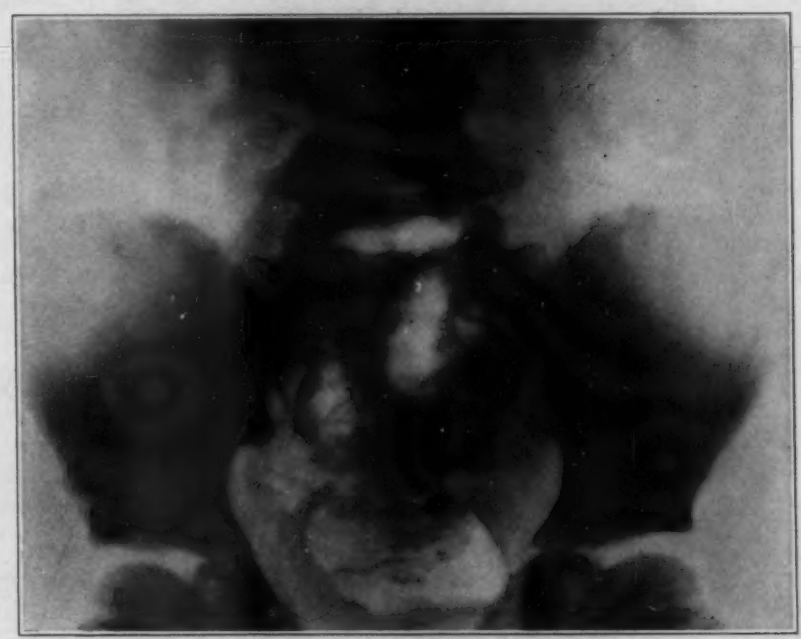

Fig. 22 (case 18).—Platyspondyly, type 3, localized form, most marked in fifth lumbar vertebra. (See text.)

Roentgenographic examination revealed (fig. 23) that the cervical vertebrae were wider than normal. This increase in width diminished gradually caudally to the third dorsal vertebra, which was of normal size. The vertical diameters of the cervical vertebrae were irregular and less than normal. The sixth cervical segment was markedly thinned and presented concavities on its superior and inferior surfaces. There was spina bifida occulta of the seventh cervical vertebra. The second and third dorsal vertebrae were abnormally narrow in their vertical diameters, while their transverse dimensions were approximately normal. It was also noted that the right scapula was situated about 1 inch cephalad in comparison to the left.

Roentgenographic study (fig. 24) of the lumbar region showed that the third, fourth and fifth lumbar vertebrae were widened in their transverse diameters and narrowed in their vertical dimensions. There was spina bifida occulta of the first

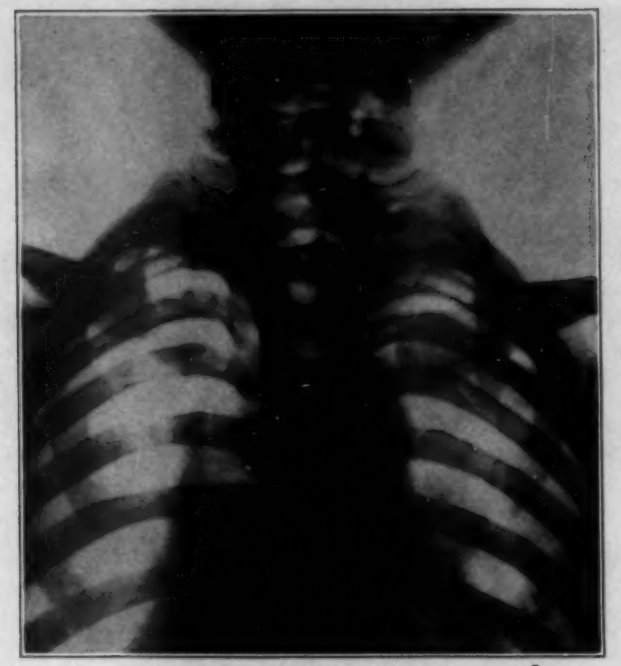

Fig. 23 (case 19).—Localized form of platyspondyly, type 3, involving the cervical and the upper three dorsal segments. The sixth cervical segment shows an extremely marked diminution of its vertical diameter with concavities on its superior and inferior surfaces. This case presented a second focus in the lumbar region. See figure 24.

Fig. 24 (case 19).—Localized form of platyspondyly, type 3, involving the lumbar region, most marked in the fifth lumbar segment. This case presented a second focus in the cervical and upper dorsal region. See figure 23.

sacral segment. The intervertebral disks in this region were abnormally thickened. (Compare table 5 with tables 2 and 4.)

CASE 20.—P. R., a 9 year old white girl, was admitted to the service of Dr. Finkelstein at the Hospital for Joint Diseases because of a mild residual paralysis of one of the lower extremities subsequent to poliomyelitis.

As an incidental finding it was noted that in the upright position the child's posture was very poor in that there was a definite increase in the posterior curva-

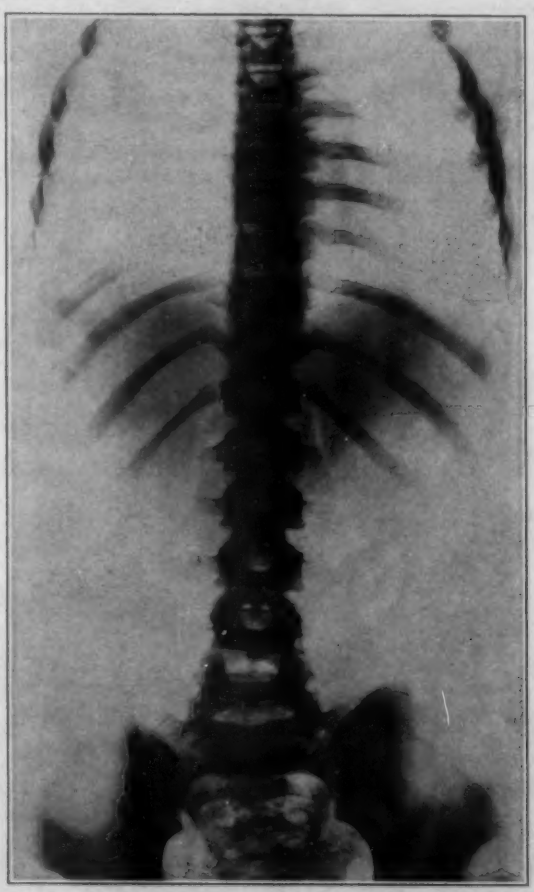

Fig. 25 (case 20).—Localized form of platyspondyly, type 3, involving the lumbar region presenting a fusiform widening of the spine, most marked in the fifth lumbar segment.

ture in the dorsolumbar region and a loss of the normal lumbar hollow. In the sitting position she presented a total posterior curve. All motions of the spine were unrestricted and painless. There was no tenderness anywhere, save over the iliac crests.

Roentgenographic study (fig. 25) revealed that beginning with the first lumbar vertebra and descending downward there was a gradual increase in the transverse

diameters and a decrease in the vertical diameters of the vertebral segments, culminating in a maximum change in the fifth lumbar vertebra. This was associated with a moderate increase in the height of the intervertebral disks.

Measurements yielded increased ratios that were indicative of the disproportion between the transverse and the vertical diameters of the vertebrae and the height of the intervertebral disks, all in the lumbar region. (Compare table 5 with tables 2 and 4.)

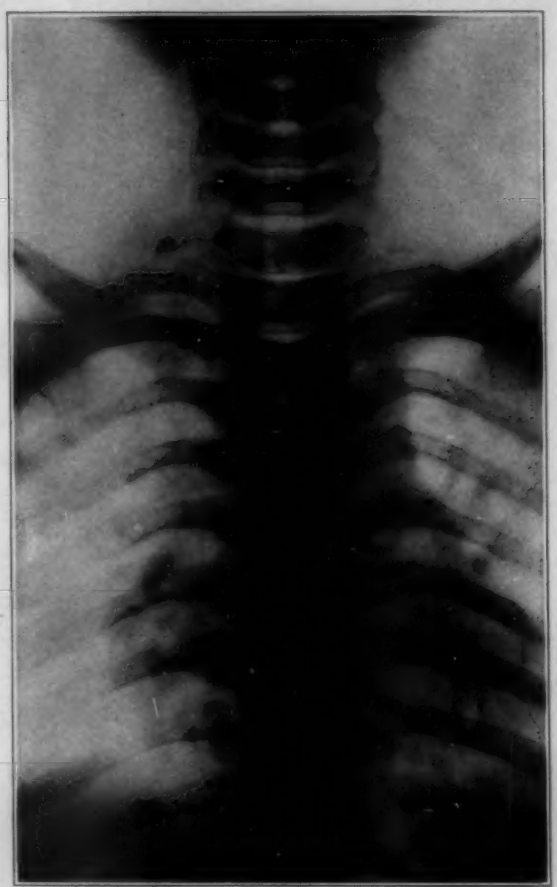

Fig. 26 (case 21).—Localized platyspondyly, type 3, of the cervical and upper dorsal segments. Note the concavities on the inferior surfaces of the cervical vertebrae and the disproportion of the various diameters.

Case 21.—W. H., an 8 year old boy afflicted with a right spastic hemiplegia associated with a cerebral retardation, while under treatment at the Hospital for Joint Diseases sustained an injury to the back of his neck.

Physical examination revealed a deep-seated cervical adenitis.

Roentgenographic examination (fig. 26) showed that the vertebrae of the entire cervical region were wider transversely than those in the dorsal segment.

The diminution in width was gradual from above downward, so that the upper dorsal vertebrae were also involved in the same process. It was also noted that the vertical diameter of the cervical vertebrae was less than normal and that the increase in height in the upper dorsal segment was gradual. Similarly, the affected vertebrae presented concavities on their superior and inferior surfaces, while the intervertebral disks were proportionately increased in height. The seventh cervical vertebra presented bilateral cervical ribs.

The ratios of the transverse diameters to the vertical diameters of the vertebrae and the ratios of the heights of the intervertebral disks to those of the adjoining vertebrae were increased beyond the normal (table 5). Comparison of these data with those shown in tables 2 and 4 bears out the visual impression that one gets on inspection of figure 26.

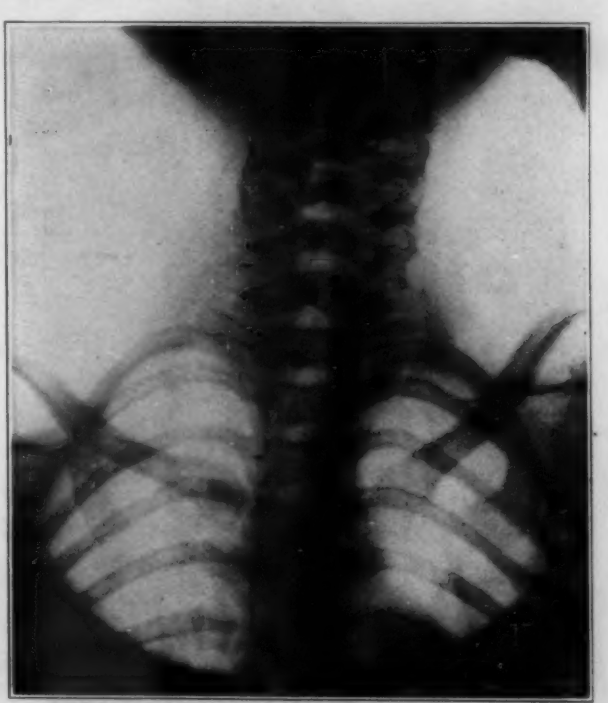

Fig. 27 (case 22).—Localized platyspondyly, type 3, of the cervical and upper dorsal region. Note the barrel-shaped enlargement of the cervical region, the concavities on the inferior surfaces and the convexities on the superior surfaces of the cervical segments.

Case 22.—S. S., a 7 year old white girl, was admitted to the outpatient department of the Hospital for Joint Diseases because of poor posture.

Clinical examination gave essentially negative results, save for the presence of a hollow round back.

Roentgenographic study (fig. 27), however, revealed a barrel-shaped enlargement of the cervical region. The entire cervical region tapering down to include the upper two dorsal vertebrae was widened transversely and narrowed vertically.

The superior surfaces of these segments presented convexities, while the inferior aspects presented concavities. The intervertebral disks were correspondingly enlarged. The seventh cervical vertebra presented in addition bilateral cervical ribs which were much more distinct in the x-ray film than in the appended print. A comparison of table 5 with tables 2 and 4 shows the numerical increase in the ratios of the transverse diameters to the vertical diameters of the vertebrae and in the ratios of the heights of the intervertebral disks to the heights of the vertebrae.

CASE 23.—S. G., a 3½ year old white boy, was admitted to the outpatient department of the Hospital for Joint Diseases because of a stiff neck. One month previous to admission he fell and had a bloody nose. Three weeks later his neck became stiff, and he had a rise in temperature, with generalized aches and pains.

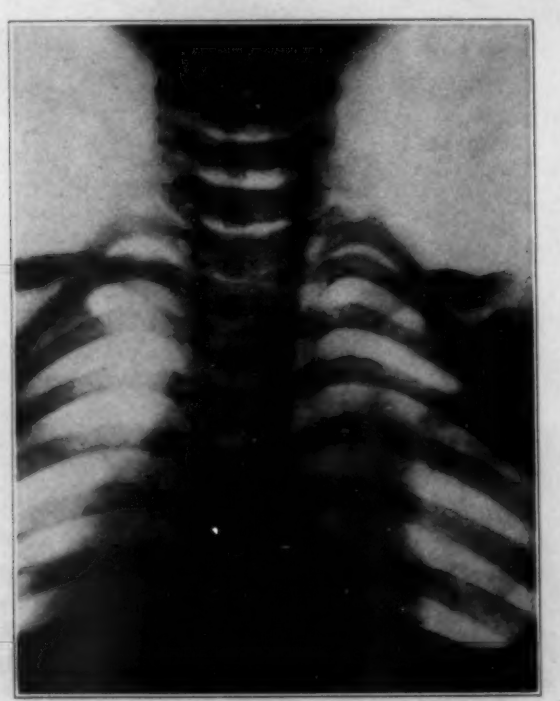

Fig. 28 (case 23).—Localized platyspondyly, type 3. Note the fusiform widening of the cervical region tapering downward to include the upper two dorsal segments.

Clinical examination gave negative results save for an enlargement of the cervical, submaxillary and inguinal glands.

Roentgenographic examination (fig. 28) revealed a fusiform widening of the cervical portion of the spine tapering downward to include the upper two dorsal vertebrae. The vertebral segments in this region were widened transversely and narrowed vertically. The intervertebral disks were correspondingly enlarged. The seventh cervical vertebra presented bilateral cervical ribs. Table 5 shows ratios obtained by measurements for this case. Comparison with the normal averages shown in tables 2 and 4 shows the increase above the normal.

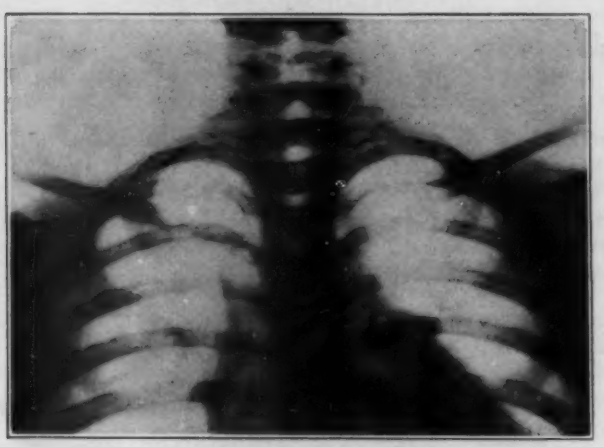

Fig. 29 (case 24).—Localized platyspondyly, type 3, involving the cervical and first dorsal vertebrae. The inferior surfaces of the cervical vertebrae are markedly concave.

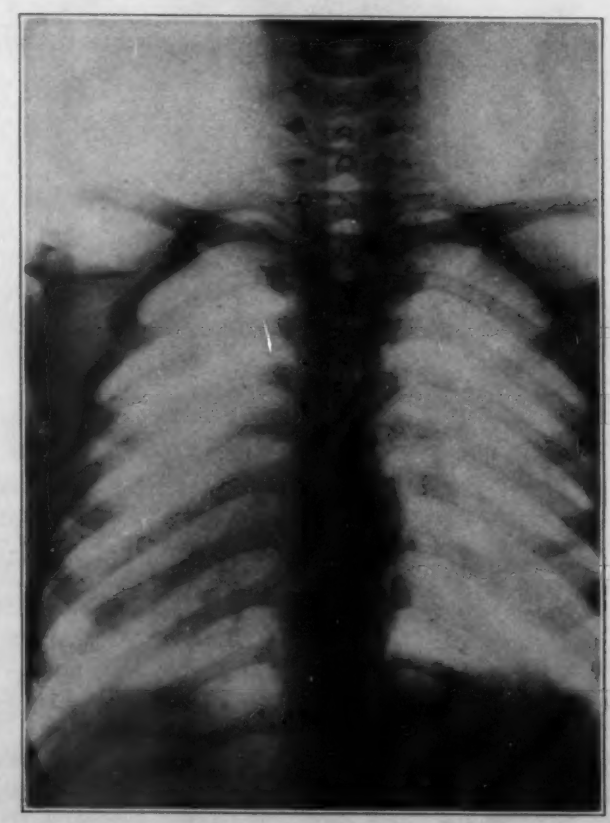

Fig. 30.—The normal appearance of the cervical and dorsal regions of an 11 year old boy. Compare with figures 29, 31 and 32.

Case 24.—E. B., an 8 year old white girl, was admitted to the outpatient department of the Hospital for Joint Diseases. The history and the results of the physical examination were not available.

Examination of the x-ray films (fig. 29) revealed that the cervical and the first dorsal vertebrae were enlarged transversely and narrowed vertically. The inferior surfaces of the cervical vertebrae were markedly concave, while the superior surfaces were mildly convex. The intervertebral disks were correspondingly increased in their horizontal and vertical diameters and conformed with the concavities and convexities of the adjacent vertebrae. There were, in addition, bilateral rudimentary cervical ribs at the seventh cervical segment. Comparison of table 5 with tables 2 and 4 shows the actual change in the relationship between the transverse and the vertical diameters of the vertebrae and the relationship between the height of the disks and that of the vertebrae.

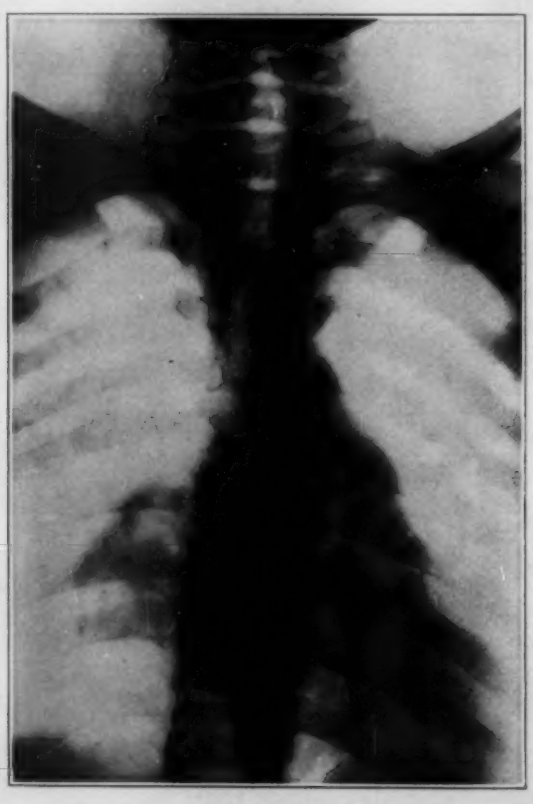

Fig. 31 (case 25).—Localized platyspondyly, type 3, of the cervical and upper dorsal vertebrae. The fifth cervical vertebra is markedly involved.

Figure 30, an anteroposterior view of the cervicodorsal region of an 8 year old child, shows the normal relationship of the transverse to the vertical diameters of the cervical vertebrae to those of the dorsal region. This appearance is to be compared with figure 29, which shows a platyspondyly, to appreciate the normal from the abnormal.

CASE 25.—A. B., an 11 year old white boy, was admitted to the outpatient department of the Hospital for Joint Diseases with the complaint of poor posture. Two years previously he suffered from empyema.

Physical examination revealed a poorly nourished, poorly developed white boy presenting kyphosis dorsalis juvenilis.

Roentgenographic examination (fig. 31) revealed typical platyspondyly of the cervical and the upper two dorsal vertebrae. The vertebrae of the involved segment were wide transversely, tapering downward to include the second dorsal segment, and were narrowed vertically, increasing in height as the lower limit of the area was approached. The fifth cervical vertebra was most characteristic in that it presented a marked concavity on both the upper and the lower surface. The seventh cervical vertebra presented bilateral cervical ribs. The changes in the vertebral diameter expressed, numerically, are shown in table 5. (Compare these values with the normal values, as shown in tables 2 and 4.)

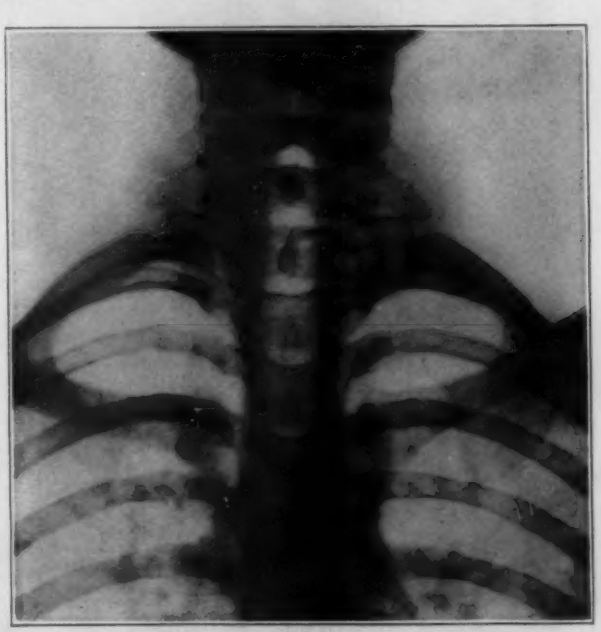

Fig. 32 (case 26).—Localized platyspondyly, type 3, of the cervical and the first two dorsal vertebrae.

CASE 26.—G. St. C., an 11 year old white girl, was admitted to the outpatient department of the Hospital for Joint Diseases because of a prominence of the back of the neck.

Physical examination gave negative results, save for a thickening of the base of the neck.

Roentgenographic study (fig. 32) revealed that the cervical region was abnormally enlarged transversely, tapering downward in width to include the first and second dorsal vertebrae. The vertical diameters of the vertebrae were diminished, increasing gradually as one approached downward to the second dorsal vertebra. There were, in addition, the typical concavities and convexities of the inferior and superior surfaces of the vertebrae. The intervertebral disks were but slightly

enlarged in their vertical diameters save at the midlines of the bodies where the enlargement was marked. Bilateral rudimentary cervical ribs were present at the seventh cervical vertebra. (Compare table 5 with tables 2 and 4.)

CASE 27.—I. B., a 25 year old woman, was seen and roentgenograms made to determine whether she had cervical ribs. The history and the results of the physical examinations were not available.

The x-ray film (fig. 33) revealed a generalized transverse enlargement of the cervical and first dorsal segments. The vertical diameters and the intervertebral

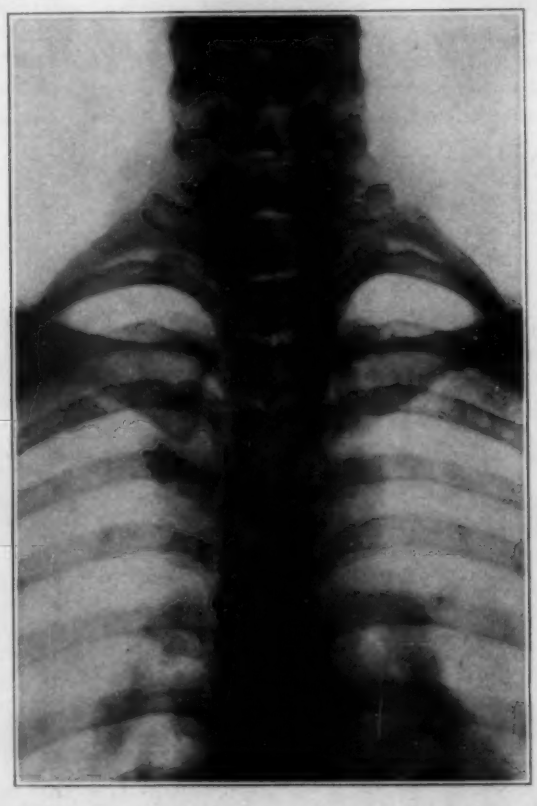

Fig. 33 (case 27).—Localized platyspondyly, type 3, of the cervical region.

disks were diminished. The inferior surfaces of the cervical vertebrae presented slight concavities. The transverse processes of the sixth and seventh cervical vertebrae were hypertrophied. (Compare table 5 with tables 2 and 4.)

CASE 28.—L. S., a 12 year old white girl, was admitted to the outpatient department of the Hospital for Joint Diseases. The history and the results of the physical examination were not available.

The x-ray film (fig. 34) culled from the x-ray files showed a fusiform enlargement of the entire cervical region, including the upper two dorsal segments. The width was greatest in the lower cervical area, thus suggesting a barrel-shaped enlargement. The vertical diameters of the segments were diminished, while those

of the intervertebral disks were increased. The transverse processes of the seventh cervical vertebra were enlarged. (Compare table 5 with tables 2 and 4.)

Figure 35 is an anteroposterior view of a normal cervicodorsal region of a 13 year old child for comparison with the abnormal appearance shown in figure 34 and others.

Case 29.—R. S., a 10 year old white girl, was treated by me several years ago at the Israel Zion Hospital for bilateral fracture of the clavicles, sustained as a result of an automobile accident. The end-result was satisfactory, and the patient had no complaint with reference to her neck.

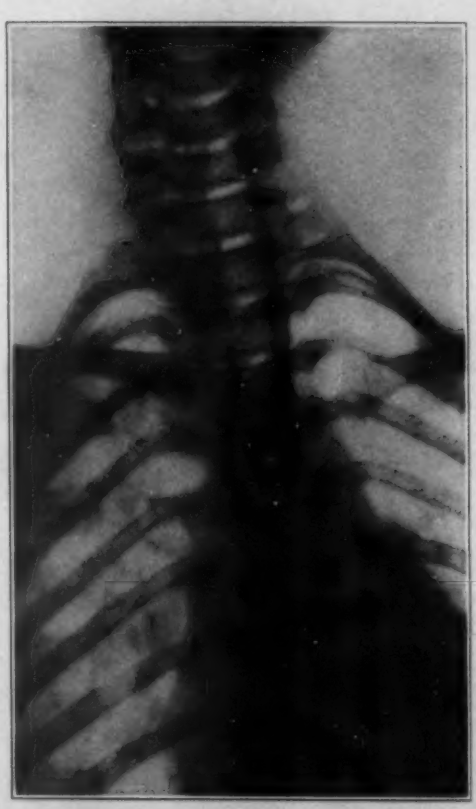

Fig. 34 (case 28).—Localized platyspondyly, type 3. Note the barrel-shaped enlargement of the cervical region.

A recent roentgenogram showed (fig. 36) as an incidental finding a marked widening of the cervical and upper dorsal vertebrae tapering down to a normal width at the second dorsal vertebra. The vertical diameters of the vertebrae were diminished in this region. Several of the segments presented concavities on their superior and inferior surfaces. There were in addition, bilateral rudimentary cervical ribs. (Compare table 5 with tables 2 and 4.)

Case 30.—I. P., a 5 year old girl, was admitted to the outpatient department of the Hospital for Joint Diseases because of pain and stiffness of the neck following a second injection of toxin-antitoxin for diphtheria.

Physical examination revealed that the child held its head with the chin tilted upward and to the left. The ranges of motion of the neck were normal in all directions. The base of the neck was found to be thickened. Physical therapy and support were instituted, and the patient was relieved of the torticollis.

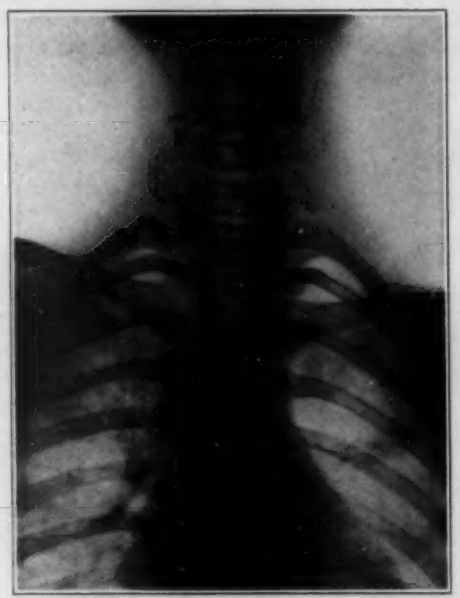

Fig. 35.—A roentgenogram of a normal cervicodorsal region of a 13 year old child, for comparison with figure 34.

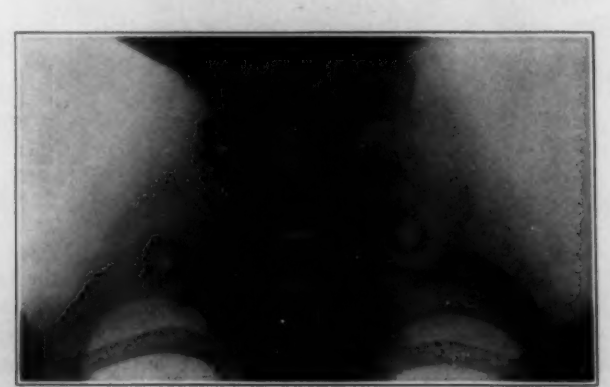

Fig. 36 (case 29).—Localized platyspondyly, type 3, of the cervical and upper dorsal region. Note the bilateral cervical rudimentary ribs.

Roentgenographic examination (fig. 37) revealed a fusiform widening of the cervicodorsal region with its greatest dimensions at the seventh cervical vertebra. The vertical diameters of the segments in this area were diminished, and the heights of the intervertebral spaces were increased. There were bilateral rudi-

mentary cervical ribs at the seventh cervical vertebra. (Compare table 5 with tables 2 and 4 for the relative ratios.) There was, in addition, a Sprengel's deformity, in that one scapula was definitely higher than its mate on the opposite side.

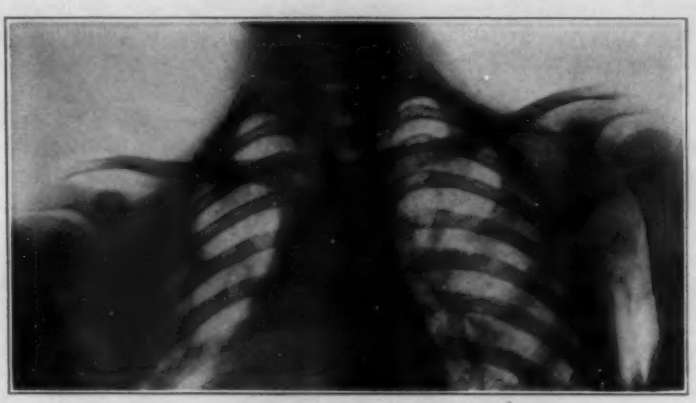

Fig. 37 (case 30).—Localized platyspondyly, type 3, of the cervical region. The associated congenital anomalies are Sprengel's deformity and bilateral cervical ribs.

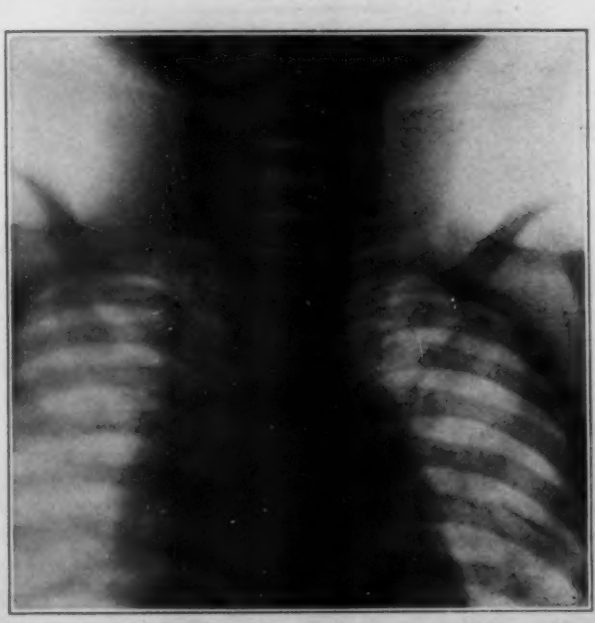

Fig. 38 (case 31).—Localized platyspondyly, type 3. The cervical region presents a barrel-shaped enlargement perched on the dorsal segment of the spine. The disproportion of the various diameters is marked.

Case 31.—R. H., a 13 month old boy, was seen in the outpatient department of the Hospital for Joint Diseases because of a flexion deformity of the left

thumb, which had been noted by the mother since birth. Physical examination gave negative results from the orthopedic aspect, save for the flexion contracture of the thumb.

Roentgenographic examination (fig. 38) of the cervicodorsal region of the spine revealed a marked disproportion in the relationship of the width to the height of the cervical vertebrae. The whole appearance was that of a barrel-shaped enlargement perched on the dorsal segment of the spine. (Compare table 5 with table 2.)

Case 32.—S. R., a 5 year old girl, was admitted to the service of Dr. Finkelstein at the Hospital for Joint Diseases because of a torticollis of five days' duration resulting from a somersault in bed. The deformity was diagnosed as an anterior subluxation of the atlas, which was relieved after several days of traction in bed.

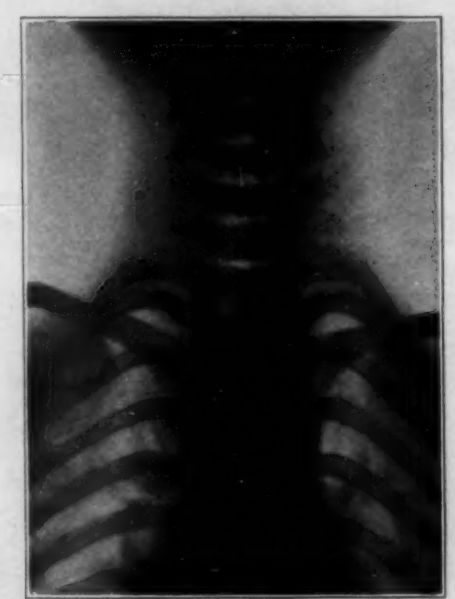

Fig. 39 (case 32).—Localized platyspondyly, type 3, of the cervical region.

As an incidental finding of the roentgenographic study (fig. 39) a disproportional widening of the transverse diameters and a diminution of the vertical diameters of the cervical vertebrae were noted. The intervertebral disks presented an increase in their vertical diameters. (Compare table 5 with tables 2 and 4.) There were, in addition, bilateral rudimentary cervical ribs.

Case 33.—S. R., a 5 year old girl, was admitted to the Hospital for the Ruptured and Crippled in 1924 for the treatment of a condition totally unrelated to her back. The history was unimportant, and physical examination gave negative results so far as the spine was concerned. This case was therefore included in a study of the normal ossification centers that was being made at that time. Roentgenograms were taken and were considered normal at that time.

A reexamination of these films brings to light that there is an increase of the transverse diameters and a disproportionate decrease of the vertical dia-

meters of the cervical and upper four dorsal vertebral bodies. A visual picture of this disturbance is shown in figure 40, while table 5 and a comparison of the values presented therein with the normal values shown in tables 2 and 4 give a mathematical picture of this condition.

CASE 34.—H. D., a 5 year old boy, was admitted to the service of Dr. Mayer at the Hospital for Joint Diseases because of a residual poliomyelitis affecting the right hand.

As an incidental finding, in the roentgenographic study (fig. 41) enlargement of the transverse diameters and a diminution of the vertical diameters of the lower

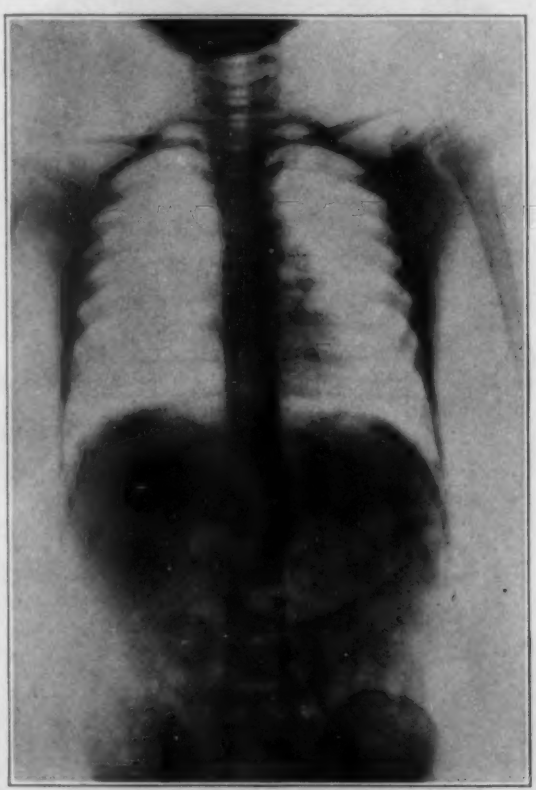

Fig. 40 (case 33).—Localized platyspondyly, type 3, of the cervical region.

cervical and upper dorsal vertebrae were noted. The intervertebral disks were markedly increased in their vertical diameters. (Compare table 5 with tables 2 and 4.)

CASE 35.—R. L., a 6 year old boy, was admitted to the service of Dr. Leo Mayer because of congenital torticollis. There was no history or physical findings referable to the patient's spine.

Roentgenographic examination (fig. 42) showed a fusiform enlargement of the cervical portion of the spine. The vertebrae were enlarged transversely and disproportionally diminished vertically. The fifth and sixth cervical vertebrae presented a failure or an incomplete fusion of the lateral masses to the centra of

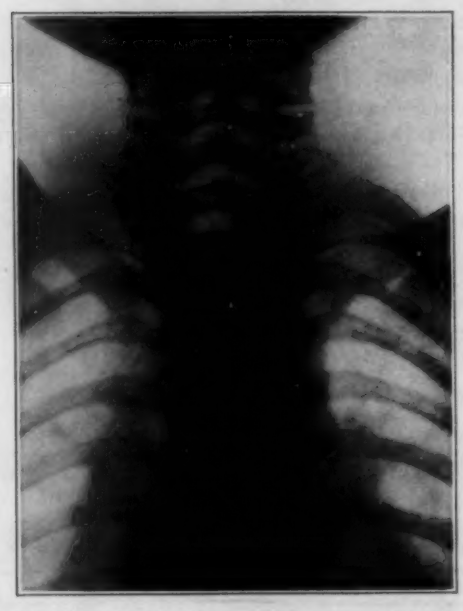

Fig. 41 (case 34).—Localized platyspondyly, type 3, of the cervical region. The disproportion is marked in the upper cervical region.

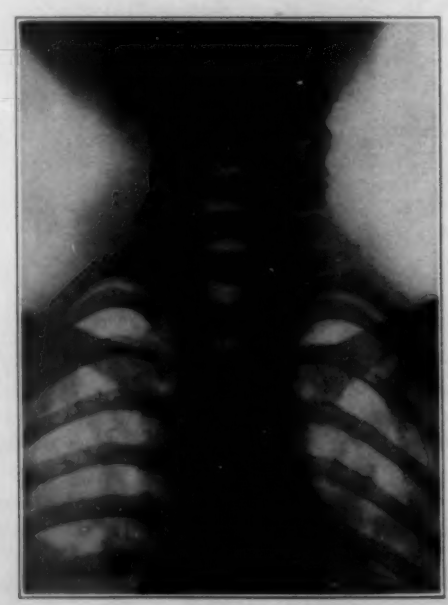

Fig. 42 (case 35).—Localized platyspondyly, type 3. Note the failure or incomplete fusion of the lateral masses to the centra of the fifth and sixth cervical segments.

the vertebrae. (See table 5 for the ratios of the respective diameters.) The seventh cervical vertebra presented, in addition, rudimentary cervical ribs.

Case 36.—I. B., a 7 year old boy, was admitted to the Hospital for the Ruptured and Crippled in 1927, for the treatment of congenital talipes. The history was unimportant, and physical examination gave negative results so far as his spine was concerned. Roentgenograms were taken at that time, for the purpose of studying the normal complementary ossification centers.

A restudy at the present time revealed (fig. 43) what was not evident at that time, namely, a disproportional increase of the transverse diameters and a lessen-

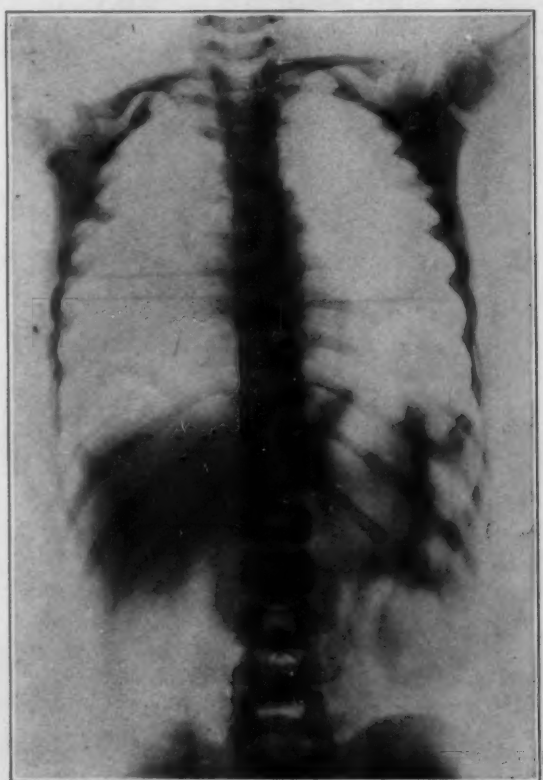

Fig. 43 (case 36).—Localized platyspondyly, type 3, of the cervical and upper two dorsal vertebrae.

ing of the vertical diameters of the cervical and upper two dorsal segments. Several of the intervertebral disks showed a disproportional increase in their vertical diameters. (Compare table 5 with tables 2 and 4.)

Case 37.—F. K., a 10 year old boy, was admitted to the Hospital for the Ruptured and Crippled in 1924 for a condition totally unrelated to his spine. Physical examination gave negative results so far as his spine was concerned. Roentgenograms were taken to observe the normal ossification of the superior and inferior vertebral epiphyses.

A restudy at the present time revealed (fig. 44) that the transverse diameters of the vertebral bodies were disproportionely increased in comparison to the ver-

tical diameters of the same segments. This disproportion began with the first lumbar body and became increasingly greater as one progressed, caudad, reaching a maximum at the fifth lumbar vertebra (table 5). The height of the intervertebral disks were not increased. There was, in addition, a failure of fusion of the posterior arch of the first sacral segment, and in the lateral views one noted a defect in the isthmus between the superior and the inferior articular facets of the fifth lumbar vertebra.

Case 38.—S. Z., a 3½ year old boy, was admitted to the Hospital for Joint Diseases for a condition totally unrelated to his spine. Roentgenograms were made of the spine for the purpose of obtaining a normal standard. Much to our surprise, a marked case of platyspondyly was found, as shown in figure 45. All of the cervical vertebrae showed a marked increase in the transverse diameters

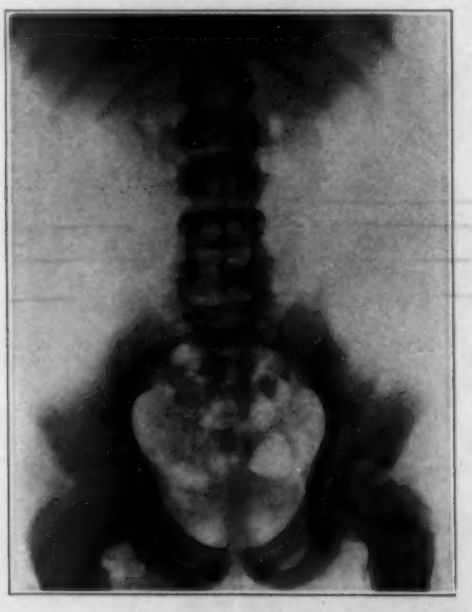

Fig. 44 (case 37).—Localized platyspondyly, type 3, of the lumbar region. The disproportions of the diameters become progressively greater from above downward.

and a decrease in the vertical diameters. The first and second dorsal vertebrae showed a diminution in the height, but no increase in the width of the bodies. The intervertebral spaces were increased. There was, in addition, a rudimentary cervical rib at the seventh cervical segment.

Comment.—Cases 18 to 38, inclusive, are examples of the localized form of the third type of platyspondyly described by Lance. The most common site of involvement in these cases is in the cervical and cervicodorsal region. The lower part of the lumbar region is the next most common area of involvement. I have not as yet noted any instance in which the other regions of the spine were affected except in the

generalized forms. In several of the cases there were two areas of localization. The great majority of the patients had associated congenital anomalies, the most frequent of which were hypertrophied transverse processes and cervical ribs. In three instances there was a unilateral or bilateral Sprengel's deformity. In another instance there was a defect in the isthmus between the superior and the inferior articular facets of the fifth lumbar vertebra. In still another instance there was a failure of fusion of the lateral masses to the centra of

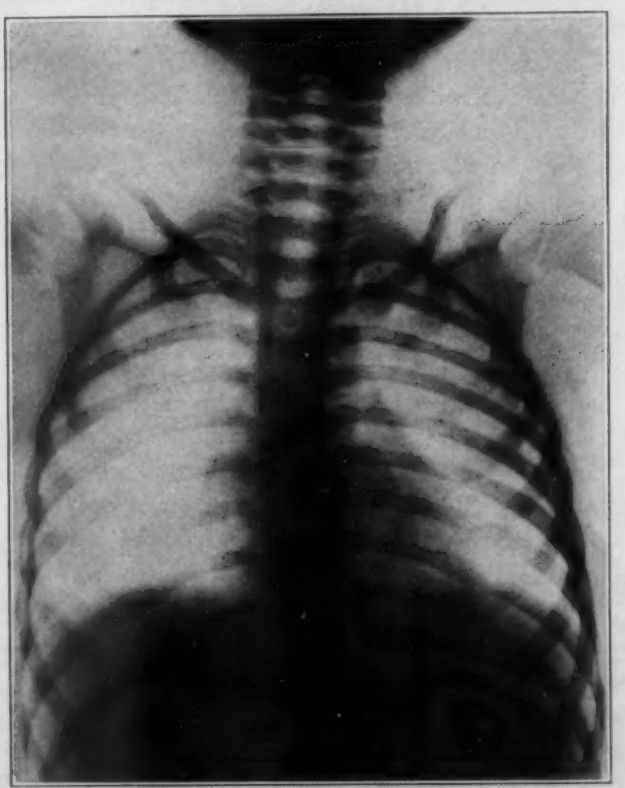

Fig. 45 (case 38).—A marked case of localized platyspondyly, type 3, of the cervical region.

two vertebrae. In addition, there were other congenital deformities, such as torticollis, talipes and a flexion deformity of a thumb. All of this serves to depict the congenital nature of this disturbance.

Clinically, the anomaly is asymptomatic, except so far as the associated condition may produce physical or symptomatic changes. Roentgenographically, the changes are very evident. This is confirmed by the ratios resulting from actual measurements on the films, as shown

in table 5, and a comparison of these with the normal values shown in tables 2 and 4. Figures 30 and 35 are views of roentgenograms of normal spines for comparison with the abnormal appearances as illustrated by the cases.

DIFFERENTIAL DIAGNOSIS

Platyspondyly is a congenital lesion of the spine in which the vertebrae in one or more segments are abnormally developed. It is usually recognized accidentally in early life, chiefly through specific changes in the roentgenographic appearance. In the anteroposterior view the vertebral bodies all seem to be increased in their transverse diameters and diminished in their vertical diameters. The superior and inferior surfaces are concave, while the intervertebral disks are biconvex, wider and higher than normally. In the lateral views the vertebrae are abnormally small in the vertical diameters and are never wedge shaped. There is practically always, except in type 3, the developmental defect of spina bifida or somatoschisis. This vertebral malformation, save in type 1, usually involves more than one spinal segment which, because of the morphologic alteration of the vertebrae, has a fusiform or truncated cone shape. The recognition of the aforementioned morphologic deviations is important in differentiating platyspondyly from other more frequent and clinically more important abnormalities, both congenital and acquired. Usually little difficulty will be encountered when an extensive portion of the spine is involved in this congenital malformation. However, should this maldevelopment affect only one or several segments of the vertebral column, the differential diagnosis may not be so apparent. The most common of the lesions from which platyspondyly has to be differentiated are: Pott's disease, compression fractures of the spine, malignant disease, vertebral epiphysitis, vertebral osteochondritis, osteoporosis, microspondyly, fetal chondrodystrophy and herniations of the nuclei pulposi.

Pott's Disease.—The usual case of Pott's disease will offer no difficulties in differential diagnosis because of the disability, the localized pain and deformity and the roentgenographic picture of rarefaction, destruction, collapse, loss of intervertebral disks and abscess formation. Occasionally, however, a case may be seen in which there is compression but no other evidence of tuberculous disease. Here, however, the vertebral body will show wedging but rarely widening in the anteroposterior roentgenogram. Moreover, there will be roentgen evidences of a destructive disease. The clinical history, the physical findings, the roentgenographic appearances and the absence of other congenital anomalies should establish the diagnosis.

Compression Fractures.—In cases of traumatic compression [1] there is always a definite history of injury, even though slight, followed by localized pain and disability with its associated physical findings of localized tenderness, muscle spasm and rigidity. The location of the lesion is usually in the lumbodorsal region, while in platyspondyly it is most commonly in the dorsal and cervicodorsal regions. In traumatic compression the onset is usually in later life. Roentgenographically there are usually no associated congenital anomalies. The compression usually results in wedging with the apex anteriorly and the base posteriorly, as seen in the lateral views, while in platyspondyly the flattening involves the entire body, and the lateral views do not present wedge formation. Definite fractures, and in old cases, variations in calcifications, callus and osteophyte formations may be noted in those cases due to trauma. The intervertebral disks may be crushed, but they are never increased in height as in platyspondyly.

Malignant Lesions.—In cases of primary and metastatic disease of the spine the subject is usually an adult, often past middle age, with a history of intense localized pain and loss of weight and frequently showing cachexia. The pain is so severe that it is modified only by large doses of sedatives. The primary focus is often evident. Locally, in the spine there are marked tenderness to pressure, rigidity and muscle spasm and in the late stages the formation of an angular deformity. The roentgenograms show an absence of those changes noted in platyspondyly, and in contradistinction there is present, in the early stages, mottling of the vertebra, and in the late period, destruction and collapse of one or more vertebrae with resultant angulation.

Vertebral Epiphysitis.—This lesion rarely occurs before the second decade. There is usually a history of abnormal tendency to fatigue, intermittent pains and increasing poor posture during the second period of rapid growth. Clinically, there may be tenderness over the spinous processes and the iliac crests and occasionally over other rapidly developing osseous centers. Gross deformities of the spine are the end-results. Roentgenographically, there are irregularities in ossification in the form of areas of condensation and rarefaction of the vertebral bodies and irregular moth-eaten superior and inferior outlines of the vertebral segments. In the later stages the vertebrae may be wedge shaped in the transverse diameters but most commonly in the sagittal diameters, and their superior and inferior outlines may be sclerosed. The intervertebral disks present a hazy, mottled and laminated appearance and occasionally evidences of herniations of the nucleus pulposus.

1. Traumatic compression of the vertebral body is sometimes designated by the French observers "traumatic platyspondyly." This, in my opinion, is confusing. The term platyspondyly should be restricted to congenital lesions.

These roentgenographic appearances are in sharp contradistinction to those in platyspondyly, which do not show abnormalities in ossification or changes in the vertebral disks other than those of shape and size.

Vertebral Osteochondritis.—Vertebral osteochondritis develops during the first period of rapid growth of the spinal column—the first few years of life. The history reveals evidences of pain and increasing deformity. Clinically, there may be indications of tenderness along the spine. Localized deformity may be present. Roentgenographically, one or several vertebrae may be involved in that there are irregularities in ossification and vertebral outlines. There may be wedging of the vertebral segments, but neither widening in the transverse diameters nor the characteristic concavities noted on the superior and inferior vertebral surfaces in instances of platyspondyly.

Osteoporosis.—The rare forms of hunger, traumatic or senile osteoporosis of the spine may present flattening of the vertebrae but never widening. The bony texture of the bodies is porotic, while in platyspondyly it is always normal. The superior and inferior borders of the vertebral outlines may be definitely concave, but these depressions are most clearly demonstrated in the lateral views, while in platyspondyly they are seen only in the anteroposterior views. The concavities usually involve the entire superior and inferior surfaces, while in platyspondyly only the midportions are involved. In osteoporosis of the spine herniation of the nucleus pulposus is common, in contradistinction to its absence in platyspondyly. In osteoporosis there are wedging and increase of the posterior curvature of the spine. Furthermore, the absence of other congenital anomalies, the history of onset, the symptoms and the physical findings will make the differential diagnosis evident.

Microspondyly.—Microspondyly presents an aplasia of the entire vertebra. The vertical diameter as well as the transverse and sagittal diameters are lessened. This anomaly has its onset in a comparatively later stage of embryonic life, the stage of ossification. Consequently the vertebrae have already been formed before this disturbance sets in, and its only effect is a generalized diminution in size. Because of its late onset it is not associated with those anomalies of the membranous stage, such as variations in number, morphology or differentiation and associated costal maldevelopments.

Fetal Chondrodystrophy.—In this condition there is widening of the vertebral bodies associated with distinguishing irregularities in outline and ossification. The intervertebral disks are not disproportionately enlarged, nor do the vertebrae present the characteristic concavities or the presence of spina bifida or somatoschisis. Congenital anomalies arising in the membranous stage are absent. Furthermore, the general

picture of disproportion in length between the extremities and the spine, the typical saddle nose, the trident hand and the premature ossification of epiphyses everywhere and the deformities of the extremities will present no difficulties in differentiating this condition from platyspondyly.

Herniation of the Nucleus Pulposus.—This pathologic condition is most evident in the lateral views of the spine, although occasionally it can be clearly demonstrated in the anteroposterior aspects. Reactive processes on the part of the bone in the form of rarefaction or increased calcification around the herniations are usually present. Herniation of the nucleus pulposus is not a clinical entity and is therefore always a part of some other disturbance, such as osteoporosis of the spine, Kümmell's disease, fractures, malignant disease or osteochondropathy.

SUMMARY

Platyspondyly, as has been shown in the preceding description and observations, is a definite congenital morphologic disturbance of the growth of the spine manifesting itself in several distinct types. Its genesis may be attributed to a failure or a delay in the fusion of the lateral halves of the vertebral anlage at its membranous stage of embryonic development. The roentgenographic changes in the vertebrae and the intervertebral disks are distinctive. They have been described in detail since they render the recognition of platyspondyly certain. Perhaps the most important aspect of this study of platyspondyly is that by establishing its essential characteristics numerous other somewhat similar but usually clinically far more important lesions of the spine may be readily differentiated.

As the ratios between the vertical diameters and the transverse diameters of normal vertebrae are fairly constant, I measured about one hundred and forty-five normal spines to establish an index. I then obtained the corresponding index in the cases of platyspondyly. A comparison of the two was convincing of the marked alterations in the lesion which is the subject of this thesis. It is believed and hoped that this phase of the work on mensuration will facilitate later reviews on platyspondyly.

Dr. Samuel Kleinberg, chief of my orthopedic service at the Hospital for Joint Diseases, and Dr. Maurice Pomeranz, director of the Roentgen Ray Laboratory of the Hospital for Joint Diseases, gave valuable advice and guidance in the study; Dr. Armitage Whitman, of the Hospital for the Ruptured and Crippled, and Dr. Leo Mayer, Dr. Harry Finkelstein and Dr. Jacob Sobel, of the Hospital for Joint Diseases, permitted me to use their material, and Dr. Leo Schwartz and Dr. Milton Wasch, of the Israel Zion Hospital, permitted me to make roentgenograms of the new-born.

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STREPTOCOCCUS HAEMOLYTICUS BACTEREMIA

A STUDY OF ONE HUNDRED AND SIXTY-EIGHT CASES

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We have had the opportunity of reviewing an unusually large number of cases of Streptococcus haemolyticus bacteremia occurring within a comparatively short period. In the five and one-half years with which this study is concerned there have been 168 such cases observed in the various medical and surgical departments of the Mount Sinai Hospital. This constitutes about one fifth of all cases of proved bacteremia occurring during the stated period. Furthermore, this group included a variety of infections of unusual interest and clinical significance, the recognition and proper interpretation of which were important not only for diagnosis but for prognosis and treatment.

Because of the comparatively high incidence of Str. haemolyticus bacteremia and the clinical importance of such infections of the blood stream, we felt that a comprehensive study of these cases would be both interesting and valuable. In this study, in a large group of consecutive cases we tried to classify the various conditions in which Str. haemolyticus bacteremia occurred and to determine the significance of the bacteriologic picture in each group of cases. The route of invasion into the blood stream was used for the grouping of the cases. Each group was further studied in relation to age, seasonal incidence, prognosis and the clinical picture observed. In analyzing the blood cultures we were also interested in the diagnostic and prognostic significance of the number of organisms cultivated from the blood stream.

REVIEW OF THE LITERATURE

The literature on sepsis elicited by various micro-organisms, including Str. haemolyticus, is fully reviewed and extensively discussed by Leschke,[1] and that of human streptococcic infections by von Lingelsheim.[2] As the scope of this paper will not permit a complete review of

From the Laboratories of the Mount Sinai Hospital.

1. Leschke, E., in Kraus, F., and Brugsch, T.: Spezielle Pathologie und Therapie, Berlin, Urban & Schwarzenberg, 1919, vol. 2, p. 1055.

2. von Lingelsheim, W. V., in Kolle, W., and Wassermann, A.: Handbuch der pathogenen Mikroorganismen, Jena, Gustav Fisher, 1928, vol. 4, p. 789.

the literature, references are limited to papers concerning certain aspects with which we were directly interested.

In 1906 Libman [3] published reports of a series of cases of Str. haemolyticus bacteremia in which there was first demonstrated the importance of blood cultures in the diagnosis and operative indications of thrombosis of the lateral sinus. These observations were later extended by Libman and his collaborators [4] and corroborated by Sondern [5] in 1911, Hays [6] in 1912 and by others. Reports on Str. haemolyticus bacteremia secondary to various foci were made by Warren and Herrick [7] in their summary of 31 cases. The mortality rate in this series was 67 per cent. The series included cases of bacteremia following scarlatinal, peripheral, otitic and pelvic infections. Erb [8] in 1923 presented a report dealing with the mortality rate, seasonal incidence and distribution of various lesions in 350 cases of Str. haemolyticus infection in children. Observations concerning sepsis following erysipelas are of special interest and will be reviewed later in this paper.

The study of epidemics of milk-borne Str. haemolyticus infection by Theobald Smith and H. J. Brown,[9] Rathery and Du Castle,[10] Capps and Davis [11] and L. H. Smith [12] included a large group of cases in which the infection was of unusual virulence, with a high mortality rate and multiple metastases. There is also published a series of reports on a single case or on small groups of cases by Dunham,[13] Miller,[14] Bourges,[15] Berghausen,[16] Eggston [17] and Ballenger.[18] Neuhof, Aufses

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13. Dunham, E. C.: Septicemia in the New-Born, Am. J. Dis. Child. **45**:229 (Feb.) 1933.

14. Miller, J. E.: Streptococcic Septicemia, U. S. Nav. M. Bull. **22**:37, 1925.

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16. Berghausen, O.: Streptococcic Septicemia, Cincinnati J. Med. **4**:376, 1923.

17. Eggston, A. A.: Clinical Pathology of Mastoiditis, with Special Reference to Bacteremia and Treatment by Blood Transfusions, Laryngoscope **40**:424, 1930.

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and Hirshfeld [19] recently published a study on 150 consecutive cases of sepsis observed in the Mount Sinai Hospital. Their study concerns cases of sepsis produced by various micro-organisms, including 64 cases of Str. haemolyticus sepsis, and deals with observations on clinical manifestations of sepsis, treatment, diagnosis and prognosis. Special consideration is given by them to what they termed preseptic and early septic phases of infections when blood cultures may be negative.

METHODS

The bacteriologic picture in the cases which formed the basis of this report was studied in our laboratories by uniform and standard methods. The following technic was employed for blood cultures:

Twenty-one cubic centimeters of the patient's blood was drawn at the bedside from an anterior cubital vein. Fifteen cubic centimeters was divided equally among three 100 cc. Erlenmeyer flasks, the first containing veal infusion broth, p_H 7.2; the second, 2 per cent dextrose-veal infusion broth, p_H 7.2, and the third, 10 per cent tomato extract-veal infusion broth, p_H 7.2. The remaining 6 cc. of blood was equally divided to form three pour plates, 2 cc. being mixed with a tube of 12 cc. of liver hormone-veal infusion agar, p_H 7.4, with a tube of 12 cc. of 2 per cent dextrose-veal infusion agar, p_H 7.0-7.4, and with a tube of 12 cc. of plain veal infusion agar, p_H 7.2, respectively.

Each of the 100 cc. Erlenmeyer flasks contained 90 cc. of fluid medium. In this manner a high degree of partial anaerobiosis was obtained as a result of the small surface exposed to oxygen as compared to the large volume of the medium.

The liver hormone-veal infusion agar was a modification of Huntoon's heart hormone agar, in which the liver was substituted for heart muscle. The final concentration of agar was 1 per cent.

The tomato broth consisted of 80 cc. of 2 per cent dextrose broth and 10 cc. of sterile tomato extract. The tomato extract was made by boiling ripe tomatoes for one-half hour. The fluid extracted in this manner was centrifugated at high speed until the solid matter settled. This procedure usually required at least one-half hour. The supernatant fluid was then filtered through Berkefeld V candles and adjusted to p_H 8.2 before it was poured into flasks. The tomato extract contained a natural useful indicator. The light straw color of the acid extract turned brown during the process of adjustment with tenth-normal sodium hydroxide when the p_H reached between 7.6 and 7.8. The adjustment from p_H 7.8 to 8.2 was then made by means of an indicator. The tomato extract offered valuable ingredients for culture mediums because of the vitamin content (Thjøtta and Avery [20] and Shwartzman [21]).

Daily transplants were made for three days from each of the flasks onto slants of 1 per cent dextrose broth-ascitic fluid agar and also into tubes containing 1 per cent dextrose-veal infusion broth. In addition, smears stained by the Gram method were examined daily from each flask containing fluid mediums.

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19. Neuhof, H.; Aufses, A. H., and Hirshfeld, S.: Pyogenic Sepsis: Survey of One Hundred and Fifty Cases, Surg., Gynec. & Obst. **58**:886, 1934.

20. Thjøtta, T., and Avery, O. Y.: Studies on Bacterial Nutrition: Growth Accessory Substance in Cultivation of Hemophilic Bacilli, J. Exper. Med. **34**:97, 1921.

21. Shwartzman, G.: Proc. Soc. Exper. Biol. & Med. **22**:7, 42 and 44, 1924.

On some occasions the smear from the bouillon flasks showed gram-positive cocci, which failed to grow on transplants. A certain percentage of these cultures yielded growth on anaerobic subcultures. The failure of the remaining blood cultures to yield growth on various mediums was apparently due to autolysis, which is frequently observed in dextrose and tomato extract mediums. In these instances, as well as in cases clinically suggestive of a general infection (sepsis) but in which blood cultures were sterile, anaerobic blood cultures were made.[22] Six additional cubic centimeters of blood was obtained for these cultures and distributed equally among Smith-Noguchi's cooked liver broth and Rosenow's brain infusion broth mediums. Two cubic centimeters of sterile melted petrolatum was poured over the surface of these mediums. On the fourth day the tubes were opened, smears were obtained and subcultures were made from each tube into cooked liver. This procedure was repeated after two days and again two weeks later.

Frequently gram-positive cocci grew in anaerobic mediums, while the aerobic mediums remained sterile. This finding does not signify that the gram-positive cocci thus obtained are strict anaerobes. Although the initial cultivation of these cocci occurred more easily in the absence of molecular oxygen, the streptococci once recovered grew well on further transplants in aerobic mediums.

Str. haemolyticus (Streptococcus beta-Brown) was identified by the appearance of the growth of transplants on solid mediums, by the hemolytic effect on the red blood cells on blood agar plates, by the retention of the Gram stain and by the chain formation of the cocci in fluid mediums. The criteria for identification suggested by Brown were followed. In addition, all gram-positive cocci obtained from blood cultures were differentiated from pneumococci by bile and serologic tests.

MATERIAL AND ANALYSIS

This paper presents an analysis of 168 cases of Str. haemolyticus bacteremia in which positive blood cultures were obtained, observed at the Mount Sinai Hospital from October 1926 to April 1932. Cases in which the condition was clinically suggestive of Str. haemolyticus sepsis but in which no bacteria were found in the blood stream were not included.

In order to classify our material, the term portal of entry was used to indicate the actual site from which Str. haemolyticus gained entry into the blood stream. This site need not coincide with the original focus of infection. Thus, an infection may spread by contiguity for a considerable distance from its original site and finally invade the blood stream via a "portal" somewhat removed from the primary infection.

The cases presented herewith were grouped whenever possible according to the portal of entry. Thus, the following classification was formulated.

A. Str. haemolyticus bacteremia following peripheral infections, erysipelas, infections of the upper respiratory tract, thrombosis of the

22. Recently anaerobic blood cultures have been included in the routine blood cultures.

lateral sinus, acute otitis media with meningitis, pulmonary infections, osseous and articular infections, surgical infections and gynecological infections.

B. Str. haemolyticus bacteremia associated with leukemia, agranulocytic angina, neoplasms, diabetes, rheumatic cardiovascular disease, tuberculosis and unknown causes. In this group no direct relationship could be established between the associated disease and the bacteremia.

Peripheral Infections.—In this group we included all the cases of Str. haemolyticus bacteremia in which the condition began with an injury of the epidermis, and an infection of the contiguous soft parts developed later. Of the 22 patients, 14 recovered and 8 died—a mortality rate of 36 per cent. Of the 16 patients whose ages ranged between 1 and 40 years, only 3 died. In the older age group, comprising 6 patients from 40 to 60 years of age, 5 died. It would therefore appear from these figures that the death rate was higher in the patients beyond the fourth decade of life. A careful analysis of the seasonal occurrence of the infections showed no relationship between the severity of the infection and the season of the year.

An analysis was also made according to the localization of the primary focus. In 6 cases the infection originated on the head, neck or trunk, while in the remaining 16 it began on the upper or lower extremities. There was no relationship between the localization of the primary focus and the severity of the disease. In 9 cases Str. haemolyticus was isolated from the primary focus as well as from the blood stream. In 3 cases a nonhemolytic streptococcus, Bacillus pyocyaneus, and Staphylococcus albus were obtained, respectively. These organisms were most likely secondary invaders or contaminants. In the remaining cases bacteriologic studies of the primary focus were not made. Lesions with the portal of entry on the extremities led to multiple and contiguous infections (11 of 16). Infections on the head and trunk remained localized.

Metastatic infections were observed in 7 patients (pulmonary lesions, infections of the bones and joints, meningitis, pericarditis, glomerular nephritis, etc.). Five (71.5 per cent) of the patients died. In contrast to this, only 20 per cent of the patients without metastases succumbed. It is apparent, therefore, that the development of a metastatic lesion was an unfavorable occurrence in this type of infection.

The analysis of the blood cultures with regard to the number of organisms present in the blood stream gave the following results:

In the blood cultures of the patients who died, growth was obtained in all the fluid and solid mediums. Of 17 blood cultures of the patients who recovered, 6 showed growth in only one fluid medium. Of the remaining 11 blood cultures, 4 were positive in all fluid mediums and 7

were positive in fluid and solid mediums. Thus, only in the blood cultures of the patients who recovered was the growth of bacteria limited to fluid mediums (10 of 17).

Erysipelas.—There were 7 cases of erysipelas associated with bacteremia. In 2 the condition followed hernioplasty; in 1 it complicated a carcinoma of the tongue; in 1 it was associated with a weeping eczema of the face, and in another it followed mastoidectomy for pneumococcus type III mastoiditis ("secondary" erysipelas).[23] The remaining 2 cases were instances of typical facial erysipelas with no demonstrable preceding lesion ("primary" erysipelas).[23] Both of these occurred in infants. The blood cultures in both cases yielded growth limited to the fluid mediums. In 1 of the cases the blood culture was positive one day before the appearance of the erysipelas lesion.

In this group 2 patients died—1 of the infants with facial erysipelas and the patient with carcinoma of the tongue.

Infections of the Upper Respiratory Tract.—There were 23 patients with such an infection. Eight died, and 15 recovered. This low mortality, of 34 per cent, attracted attention because of the contrast to the much higher death rates in cases of Str. haemolyticus infection originating from other foci. All patients had a history of an infection in the upper respiratory tract. In 20, the infection was diagnosed as pharyngitis without pulmonary involvement. The remaining 3 patients included 2 with tonsillitis, 1 with a peritonsillar abscess and 1 with an infection following tonsillectomy. The foregoing conditions were the only primary foci which could be discovered clinically.

Fifteen patients were between the ages of 1 and 5 years, 6 between 5 and 20 and the remaining 2 were 40 and 72 years old, respectively. There was, thus, an unquestionable predilection for persons in the early years of life. Only 3 cases occurred during the summer and 2 in the fall (November). The remaining 18 cases occurred during the winter and early spring (March and April). This group, therefore, showed a definite seasonal incidence.

We were strongly impressed by the fact that osteomyelitis of the long bones developed in 10 of the 23 patients in this group, and that only 1 of these patients died. Eight of those who recovered were under 4 years of age, and the ninth patient was 6 years old. The patient who died was 11. In each instance only one bone was involved, and the osteomyelitis was either the first or the only complicating condition. Osteotomy and drainage were performed on 8 patients and incision and drainage on 2.

Five of the remaining 6 patients who recovered and 3 of the 8 who died had multiple secondary foci.

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23. See the discussion on page 95.

The blood cultures of most of the patients who died showed a considerable number of streptococci in the blood stream. Of the blood cultures of 15 patients who recovered 11 were positive in fluid mediums only and 4 in all mediums. Of the 11 just mentioned, 5 showed growth in only one of the fluid mediums. It is interesting that in the blood cultures of the 9 patients who recovered from osteomyelitis, organisms grew in fluid mediums in only 6 instances.

Thus, we are dealing in this group with a type of Str. haemolyticus bacteremia originating in the upper respiratory tract and occurring for the most part in children during the winter and spring months. Apparently, these infections of the blood stream have a favorable prognosis and show a definite predilection for long bones.

TABLE 1.—*Blood Cultures in Cases of Thrombosis of the Lateral Sinus*

Preoperative Blood Cultures				Postoperative Blood Cultures			
Fluid Mediums Only				Fluid Mediums Only			
1 Medium*	2 Mediums†	3 Mediums‡	All Mediums	1 Medium*	2 Mediums†	3 Mediums‡	All Mediums
14	4	15	33	2	3	10	17
Total, 66				Total, 32			

* Usually tomato or dextrose broth.
† Usually tomato and dextrose broth.
‡ Tomato, dextrose and plain broth.

Thrombosis of the Lateral Sinus.—Data as to blood cultures in the cases of this condition are presented for a longer period, of seven years. During this time, operations for thrombosis of the lateral sinus were performed on 63 patients. The results of preoperative blood cultures were as follows:

In 2 cases no blood cultures were taken; in 2 the blood cultures were reported sterile; in 1 B. pyocyaneus was isolated, and in another, B. proteus, and in 57 cases Str. haemolyticus was found in the blood stream in variable numbers. Thus, the preoperative blood cultures were positive in 96.7 per cent of the cases. The large amount of blood taken for cultivation, the employment of a variety of solid and fluid mediums and repeated cultures were all important factors in obtaining this high incidence of positive cultures. In view of the practical importance of a positive blood culture in the diagnosis and operative indication of thrombosis of the lateral sinus, these figures are summarized in table 1.

As is seen from table 1, bacterial growth occurred in fluid mediums alone in 50 per cent of the preoperative blood cultures. Of these positive cultures, 21.2 per cent showed organisms in only one of the fluid mediums. Of the postoperative blood cultures, bacterial growth was restricted to fluid mediums in 44 per cent of the cultures and to one fluid medium in 13 per cent of the cultures.

Further analysis of this group concerns only 43 of the 66 cases which occurred during the five and one-half year period originally considered in this presentation. In these instances, 27 of the patients recovered and 16 died—a mortality rate of 37 per cent. Thirty-three of the patients were less than 15 years of age, and none was over 50. Thus, there was a predilection for the early years of life. There was no predominant seasonal incidence. The main metastatic foci in this group of cases occurred in the kidneys, lungs, bones and joints. Intracranial involvement was the most common fatal complication.

Acute Otitis Media with Meningitis.—There were 4 cases of acute otitis media with meningitis in which numerous streptococci were found in the blood stream. They all resulted fatally. As infection of the middle ear alone does not produce bacteremia, the meningitis had to be considered as the source of the invasion of the blood stream.

All cases occurred in the winter and spring. In 3 cases there were no secondary foci, most likely because of the fulminating course.

Pulmonary Infections.—There were 8 cases of pulmonary infection with a mortality of 100 per cent. The primary foci were bronchopneumonia in 4 instances, a more extensive pneumonitis in 2 and abscess of the lung in 2. Three cases occurred during the winter months and 5 in the spring. The high mortality and the occurrence of the pulmonary infections during the winter and spring months were outstanding features of this group. Only 1 case (i. e., abscess of the lung) followed influenza. All the blood cultures showed numerous colonies in all mediums.

Osseous and Articular Infections.—There were 8 patients with osseous or articular infection, 5 of whom died. Five patients were infants, and of these, 4 died, indicating both the high incidence and the high mortality in the early years of life. No surface infections or infections of the upper respiratory tract were observed clinically. The osseus infections (diaphyses and epiphyses of the long bones, bones of the skull, vertebrae and joints) observed in these cases were considered as primary foci. Metastatic foci, such as bronchopneumonia, abscesses of the soft parts distant to the osseus infections and meningitis, were conspicuous.

Surgical (Postoperative) Infections.—There were 20 cases of Str. haemolyticus bacteremia following various surgical procedures, such as major operations on the genito-urinary and gastro-intestinal tracts, ethmoidectomy and certain minor operations. Seventeen of the patients died, resulting in the high mortality rate of 85 per cent. It was noted that the age and season had no effect on this high mortality.

Metastatic and contiguous infections, in the order of their frequency, were peritonitis, bronchopneumonia, endocarditis and erysipelas.

Gynecological Infections.—In a series of 10 cases of bacteremia which developed following a primary infection of the uterus and adnexa (6 cases of abortion, 2 cases of puerperal sepsis, 1 case of tubo-ovarian abscess with peritonitis and 1 case of endometritis with ovarian abscess), there was a mortality of 60 per cent. Operation was performed on 1 patient only (endometritis with ovarian abscess), and in this case the

TABLE 2.—*Str. Haemolyticus Bacteremia Associated with Miscellaneous Diseases or Occurring as Secondary Invaders*

Diseases	No. of Cases	Portal of Entry	No. of Deaths	Secondary Foci	Blood Culture Mediums	Points of Interest
Leukemia	3	Pharynx, 2 cases; submaxillary infection, 1 case	3	None	All mediums	Age, 46-60
Agranulocytic angina	1	.....	1	None	All mediums, numerous organisms	
Neoplasm	6	Site of operation, 4 cases; cancer of tongue with erysipelas of face, 1 case; cancer of stomach 1 case	5	Pericarditis (sarcoma of femur), 1 case	Fluid medium (recovery), 1 case; all mediums, 5 cases	Age in fatal cases, 37-60; age of patient with cancer of breast who recovered, 25; no case in summer and fall
Diabetes	3	Infection of leg	2	None	Fluid medium (recovery), 1 case; all mediums, 2 cases	Infection of leg
Rheumatic cardiovascular disease	2	.....	1	None	Fluid medium (recovery), 1 case; all mediums, 1 case	Bacteremia with acute endocarditis in fatal case; bacteremia with no endocarditis in case of recovery
Tuberculosis	1	Pulmonary tuberculosis	0	None	Fluid medium (recovery)	
Unknown	7	.....	5	Meningitis, 3 cases; acute endocarditis, 2 cases; peripheral abscess, 1 case	All mediums, numerous organisms	Meningitis in 3 infants; all cases in winter and spring

blood culture was positive before the operative procedure. The bacteremia in these cases was complicated by infection of the soft parts, bronchopneumonia or endocarditis.

In this small group of cases the number of organisms present in the blood stream was significant for prognosis. Blood cultures of the 4 patients who recovered showed growth only in the fluid mediums, while those of the patients who died showed numerous colonies on solid mediums as well.

Associated Miscellaneous Nonbacterial Diseases.—In 23 cases Str. haemolyticus bacteremia occurred in association with one of several miscellaneous diseases (table 2). The number of cases in each subgroup was too small to permit individual analysis. The primary disease in this group was usually not an infectious process. Invasion of the blood stream occurred secondarily, often shortly before death in patients with markedly diminished resistance.

Seventeen of the patients died. The organism usually grew in all the mediums. In the 4 cases in which organisms were cultivated from fluid mediums only, recovery from the infection took place.

TABLE. 3—*Mortality Rates in Entire Group of Cases*

Group	Number of Cases	Mortality Percentage
Secondary erysipelas	5	20
Infections of the upper respiratory tract	23	34
Peripheral infections	22	36
Thrombosis of the lateral sinus	43	37
Primary erysipelas	2	50
Gynecological infections	10	00
Osseous and articular infections	8	62
Associated nonbacterial diseases	23	74
Surgical infections	20	85
Acute otitis media with meningitis	4	100
Pulmonary infections	8	100
Total	168	54

COMMENT

In these cases of Str. haemolyticus bacteremia there was a close correlation between the bacteriologic picture and the clinical significance. We have observed that the occurrence of a positive blood culture with the technic employed indicated a general infection (septicemia) clinically. In this series no positive blood cultures were encountered in cases in which such a general infection was absent.

It should be noted that certain features in our blood culture technic were apparently responsible for the high percentage of positive blood cultures obtained. We refer particularly to the large quantity of blood drawn, the variety and enrichment of the mediums employed, the careful adjustment of p_H of the mediums and the daily subcultures, spreads and prolonged observation. The sensitivity of our routine mediums has been checked at various times by simultaneous comparison of our results with those obtained by a number of recommended procedures,

including the method of Cecil, Nicholls and Stainsby,[24] various anaerobic methods,[25] and Friedberg's [26] recently described method using Kendall's mediums, and none of these showed a higher incidence of positive blood cultures.

The efficacy of our blood culture methods has been demonstrated by our experiences with diseases proved to be associated with bacteremia. Thus, in thrombosis of the lateral sinus, a condition in which the blood stream is invaded at some time during the course of the disease, positive blood cultures were obtained in 96.7 per cent of the cases over a seven year period. Also, during a similar period with which this study is concerned, in 95.5 per cent of the cases of subacute bacterial endocarditis in which autopsy was performed, nonhemolytic streptococci (alpha) had been cultivated from the blood stream by a similar technic.[27]

We have been especially interested, while studying these blood cultures, in the clinical significance of the growth of hemolytic streptococci in fluid mediums alone as distinguished from growth in both fluid and solid mediums. We have been able to establish certain diagnostic and prognostic criteria from these observations.

Growth in both fluid and solid mediums was interpreted to indicate the presence of large numbers of organisms in the blood stream, whereas growth restricted to fluid mediums indicated a paucity of organisms. This becomes clear when one considers that inoculation of a single bacterium into a fluid medium yields a high concentration of bacteria in from twenty-four to forty-eight hours. On the other hand, similar inoculations into a solid medium will yield only a single colony. Furthermore, the initially inoculated bacterium is much less likely to survive on a solid medium than in a fluid medium.

The most striking observation which this study presents was that every positive blood culture of Str. haemolyticus was associated with clinical indications of invasion of the blood stream. In other words, in every case the condition was a "frank" bacteremia and clinically significant, while what is known as a "transitory" and clinically insignificant bacteremia with no evident portal of entry was not encountered. This also applied to cases in which growth was limited to fluid mediums, even to one fluid medium. Thus, in the cases of peripheral infection,

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24. Cecil, R. L.; Nicholls, E. E., and Stainsby, W. J.: The Bacteriology of the Blood and Joints in Chronic Infectious Arthritis, Arch. Int. Med. **43**:571 (May) 1929.

25. Cohen, J.: The Bacteriology of Abscess of the Lung and Methods for Its Study, Arch. Surg. **24**:171 (Feb.) 1932.

26. Friedberg, C. K.: A Comparative Study of Blood Cultures Taken with Kendall and Routine Mediums, Arch. Int. Med. **52**:120 (July) 1933.

27. Libman, E.: Characterization of Various Forms of Endocarditis, J. A. M. A. **80**:813 (March 24) 1923.

infection of the upper respiratory tract and thrombosis of the lateral sinus, conditions in which a positive blood culture was very important for diagnosis, 48 per cent of the blood cultures were positive in fluid mediums only. Furthermore, in 36 per cent of these positive blood cultures growth occurred in one fluid medium. In every one of these cases the blood stream was being fed by a demonstrable septic focus.

Growth of nonhemolytic streptococci (alpha and gamma-Brown) confined to fluid mediums does not have the same clinical implication as indicated previously for hemolytic streptococci. Such a bacteremia might belong to the transient variety and be clinically unimportant.[27] In a recent analysis of cases of nonhemolytic streptococcus bacteremia, Lichtman and Gross [28] showed that in a consecutive series of 5,233 blood cultures performed in the laboratories of the Mount Sinai Hospital by the same technic and during approximately the same period as those reported here positive cultures were obtained in only 6+ per cent of the cases of rheumatic fever and other arthritides. On the other hand, in control cases of leukemia, anemia, colitis, meningococcus meningitis and renal infections, approximately the same percentage of positive results was obtained, indicating that the positive blood cultures in both groups were probably obtained in cases of transient bacteremia. Apparently these organisms are common inhabitants of the gastro-intestinal and respiratory tracts and occasionally gain temporary entrance into the blood stream despite the absence of a local infection. Such absorption occurs more readily in the presence of a debilitating disease, in which the barrier between the upper respiratory or gastro-intestinal tract and the blood stream becomes more permeable. The same mechanism probably explains the cases of invasion of the blood stream reported by Epstein and Kugel [29] and by Burn.[30] Experimental confirmation of this point of view has been submitted by Desoubry and Porcher,[31] who demonstrated that blood cultures of horses which were positive after a heavy fatty meal became sterile several hours later.

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28. Lichtman, S. S., and Gross, L.: Streptococci in the Blood in Rheumatic Fever, Rheumatoid Arthritis and Other Diseases, Arch. Int. Med. **49**:1078-1094 (June) 1932.

29. Epstein, E. Z., and Kugel, M. A.: Significance of Postmortem Bacteriological Examination, with Special Reference to Streptococci and Enterococci, J. Infect. Dis. **44**:327, 1929.

30. Burn, C. G.: Experimental Studies of Postmortem Bacterial Invasion in Animals, J. Infect. Dis. **54**:388, 1934; Postmortem Bacteriology, ibid. **54**:395, 1934.

31. Desoubry, M. G., and Porcher, M. C.: Compt. rend. Soc. de biol. **47**:101, 1895.

Even this small percentage of blood cultures yielding nonhemolytic streptococci in cases in which they are clinically insignificant must be distinguished from cases of frank bacteremia associated with a septic focus. Such a distinction, especially important in cases in which subacute bacterial endocarditis is suspected, can actually be made on bacteriologic grounds alone. Thus, Libman pointed out that if repeated blood cultures are made in a given case, uniformly positive results with growth in all fluid and solid mediums substantiated the presence of subacute bacterial endocarditis, whereas intermittently positive cultures with growth only in fluid mediums indicated an insignificant transitory bacteremia. The accuracy of this assumption has been repeatedly demonstrated by correlation with the clinical course and autopsy observations. Comparing these observations with the results of our study, we must conclude that whereas the nonhemolytic streptococci in fluid

TABLE 4.—*Relationship of Quantitative Number of Organisms to Mortality Rates (Prognosis)*

Group	Total Cases	Total Mortality Percentage	No. of Fatal Cases	Positive Culture in All Mediums in Fatal Cases	No. of Cases of Recovery	Positive Culture in Fluid Mediums in Cases of Recovery
Infections of the upper respiratory tract	23	34	8	5	15	11
Peripheral infections	22	36	5	5	17	10
Thrombosis of the lateral sinus	43	37	16	9	27	15
Gynecological infections	10	60	6	6	4	4
Associated nonbacterial infections	23	74	17	17	6	4
Pulmonary infections	8	100	8	8		

mediums only may indicate an insignificant transient invasion of the blood stream, the growth of hemolytic streptococci in fluid mediums indicates a significant frank bacteremia.

It is interesting from a prognostic consideration that the mortality rate was the lowest in the groups of cases in which there was the larger percentage of positive blood cultures in fluid mediums only (peripheral infections, infections of the upper respiratory tract and thrombosis of the lateral sinus). Even in the groups in which the death rate was high, the cases of recovery were usually those in which cultures of the blood showed growth restricted to fluid mediums (gynecological infections, associated nonbacterial diseases). The high mortality associated with the cases of acute otitis media with meningitis and pulmonary infections (100 per cent in our series) is well known. Of special interest because of its clinical importance and comparatively frequent occurrence is the group of surgical postoperative infections, for which the mortality rate, 85 per cent, is the third highest.

Erysipelas.—The question whether the blood stream is invaded by streptococci from lesions of erysipelas is still an unsettled issue. For this reason we are discussing this subject in greater detail.

The early work of Nepveu (1870), Winkel (1886) and Fraenkel (1903) demonstrated the postmortem presence of streptococci in the heart blood of persons who died of erysipelas. Of more interest are studies on antemortem blood cultures. According to Libman,[32] positive blood cultures occur in a small group of cases of erysipelas (11 of 100) either as a result of incision into or near carcinomatous tissue or when erysipelas is associated with a chronic disease, such as nephritis or valvular disease, or when mucous membranes are involved. Erb [8] claimed that bacteremia associated with erysipelas is more likely to occur in infants. Cultures were made in 37 cases by Sprunt (1916),[33] who obtained 5 positive growths. Four of these patients died. Laache (1923) [38] recovered Str. erysipelatis from the blood in cases of severe or fatal involvement. Birkhaug (1930)[33] isolated Str. haemolyticus (beta) from the heart blood in 8 of 11 fatal cases.

Before discussing the cases of our series it is necessary to establish a possible differentiation between "primary" and "secondary" erysipelas. By primary erysipelas is meant an infection at the site of an unrecognizable or mild local injury, with subsequent invasion of the cutaneous layers and spread by the lymphatic vessels. It is generally accepted at present that this condition is due to a specific etiologic factor. The specificity of the offending organism can be established by serologic studies and by the effect of a specific bacteriophage (Shwartzman,[34] Walker [35] and Birkhaug [36]). Duran-Reynals recently demonstrated that filtrates of Str. haemolyticus of erysipelas origin and certain other organisms contain substances which enhance cell permeability to a marked degree. These factors may be responsible for the aggressiveness and spreading powers of this streptococcus in tissues of normal resistance. For these reasons it appears that the characteristic pathologic picture in cases of primary erysipelas is due entirely to the spreading

32. Libman, E.: General Infection by Bacteremia, Lectures on Medicine and Surgery, New York Academy of Medicine, New York, Paul B. Hoeber, Inc., 1927, p. 69.

33. Thomson, D., and Thomson, R.: Quoted in Rôle of Streptococci in Erysipelas, Ann. Pickett-Thomson Research Lab. **7**:1, 1931.

34. Shwartzman, G.: Studies on Streptococcus Bacteriophage: Powerful Lytic Principle Against Hemolytic Streptococci of Erysipelas Origin, J. Exper. Med. **46**:497, 1927.

35. Walker, J. E.: Resistance of Scarlet Fever Streptococci to Action of Bacteriophage, J. Infect. Dis. **45**:304 (Oct.) 1929.

36. Birkhaug, K. E.: Erysipelas, in Nelson Loose-Leaf Living Medicine, New York, Thomas Nelson & Sons, 1929, vol. 1, chap. 16, p. 447.

property of the invading organism. It appears to us that on the basis of bacteriologic investigations thus far made on the etiology of erysipelas, there is no doubt about the specificity of Str. haemolyticus-erysipelatis for primary erysipelas.

The primary type of erysipelas should be sharply differentiated from secondary erysipelas complicating a surgical wound or a lesion of the skin or mucous membrane. In this condition the spreading lesion is apparently due not to the peculiar aggressiveness of the invading micro-organism but to a lowering of the resistance of the tissues by preceding extensive trauma or pyogenic infection. In some of our cases traumatized tissues were infected either by Str. haemolyticus or by some other micro-organism (Pneumococcus, Staphylococcus) long before the lesion of erysipelas appeared. These hemolytic streptococci represented a heterogeneous group of Str. pyogenes and could not be identified as the real Str. haemolyticus-erysipelatis by bacteriophage and serologic tests.

In the analysis of the positive blood cultures in cases of erysipelas the differentiation just discussed should be kept in mind. During the five years with which this paper is concerned, there were 18 cases of facial erysipelas which could be classified as primary. Blood cultures were sterile in 16 of these and in 2 growth of Str. haemolyticus was obtained. The relation of the age to the occurrence of positive blood cultures is noteworthy and corroborative of the observations recorded by Erb. In the 11 cases which occurred in adults, all the blood cultures were sterile. Of the 7 cases in infants, positive blood cultures were obtained in 2. In 1 case the blood culture was positive one day before the appearance of the erysipelas lesion.

It is significant that the number of bacteria present in the blood stream in the 2 cases of facial erysipelas was apparently small as only fluid mediums yielded growth. It seems that in order to obtain positive blood cultures in these cases large amounts of blood should be repeatedly cultured early in the disease.

As evidenced by our series of cases, secondary erysipelas is not infrequently associated with Str. haemolyticus bacteremia. This must be borne in mind in the consideration of the differential diagnosis of conditions which include a secondary erysipelas infection.

SUMMARY

In this study 168 cases of Str. haemolyticus bacteremia were described and classified according to the portal of entry of the organism.

Ninety-one of the 168 patients died—a mortality rate of 54 per cent. A mortality rate ranging from 60 to 100 per cent was encountered in

the cases of the following conditions: gynecological infections, articular and osseous infections, miscellaneous nonbacterial conditions associated with Str. haemolyticus bacteremia, surgical postoperative infections, pulmonary infections and acute otitis media with meningitis. In contrast to these, the mortality rate in the cases of secondary erysipelas was 20 per cent; of infections of the upper respiratory tract, 34 per cent; of peripheral infections, 36 per cent; of thrombosis of the lateral sinus, 37 per cent, and of primary erysipelas, 50 per cent.

Ninety-one per cent of the cases in which the primary focus was located in the respiratory tract (pulmonary infections, infections of the upper respiratory tract, acute otitis media with meningitis) occurred in the winter and spring. The remaining conditions manifested no particular seasonal influence.

Infections of the upper respiratory tract, thrombosis of the lateral sinus and osseous and articular infections showed a tendency to occur during the early years of life. The other conditions evidenced no predilection for a special age. In the group of peripheral infections, the mortality during the middle years of life was considerably higher than during the earlier years of life (75 per cent as compared to 25 per cent).

The enrichments of the blood culture mediums and the blood culture methods employed were largely responsible for the high incidence of these blood cultures which were positive for Str. haemolyticus, especially when limited to fluid mediums.

The quantitative estimation of the number of hemolytic streptococci in the blood stream (i. e., growth of the bacteria in both solid and fluid mediums or in fluid mediums only) had both diagnostic and prognostic significance.

The conspicuous groups illustrating the diagnostic value of these blood cultures were the cases of thrombosis of the lateral sinus, infection of the upper respiratory tract and peripheral infection. In the cases of thrombosis of the lateral sinus, 50 per cent of the preoperative blood cultures showed growth in fluid mediums only, and growth appeared in but one fluid medium in 21 per cent of these cultures. In the cases of infection of the upper respiratory tract and of peripheral infection bacterial growth was restricted to fluid mediums in 61 per cent and 45 per cent, respectively, of all cultures.

The prognostic import of the results of these blood cultures is demonstrated by the fact that in the groups in which the mortality was relatively low a high percentage of the blood cultures were positive in fluid mediums only, while in the groups with relatively a high mortality there was a high percentage of positive blood cultures in both solid

and fluid mediums. It is significant that all patients with the gynecological and associated nonbacterial infections whose blood showed growth in fluid mediums only recovered.

Of interest among the cases of infection of the upper respiratory tract was the group in which metastases to the long bones developed. This condition manifested a predilection for young children (10 cases), with a tendency toward complete recovery (90 per cent) and a small number of organisms in the blood stream in a majority of the cases (fluid mediums only 60 per cent).

The data embodied in this paper disclose that in contrast to nonhemolytic streptococci (alpha and gamma) the finding of Str. haemolyticus (beta) in the blood stream, even in extremely small numbers, was of important clinical significance for diagnosis, prognosis and indication for surgical intervention.

LATE EFFECTS OF VARIOUS TYPES OF TRAUMA TO THE KIDNEY

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The occurrence of injury to the kidney from physical force presents a problem which may tax the diagnostic experience and acumen of the surgeon to the utmost. The steady rise in the number of automobile accidents throughout the country has led to a corresponding increase in the number of injuries to the kidney, which is reflected in the literature by several reports of extensive series of such cases by Schenck,[1] Osgood and Campbell[2] and Wood.[3] In these reports the physical mechanism of the injury, the difficulties in diagnosis and the possibility of concomitant injury to other structures have been reported in detail. The methods of combating shock, which is present in a high percentage of cases of acute injury, and the points on which the surgeon's choice of operative or expectant treatment is based, are discussed in detail. In most of the series of case reports the discussion of the indications for treatment are based entirely on the extent of the injury received, and little emphasis is placed on the late result of such an injury in the kidney itself or in its surrounding structures. This is natural, as the largest series of cases are reported from the active accident services of busy metropolitan hospitals, in which a follow-up of the late results is practically impossible. Several series of cases of gunshot wounds of the kidney were reported during the World War, but here again emphasis has been laid on the treatment of the acute injury, and no information is available as to the remote effect of the injury on the kidney. The exigencies of the medical service during those days and the fact that such patients who recovered from their injuries were of necessity passed through numerous hospitals would make a follow-up study of the late effects of the injuries extremely difficult to carry out.

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1. Schenck, G. F.: Traumatic Rupture of the Kidney, California & West. Med. **40**:341-346 (May) 1934.

2. Osgood, A. T., and Campbell, M. F., in Lewis, D.: Practice of Surgery, Hagerstown, Md., W. F. Prior Company, Inc., 1929, vol. 8, chap. 5.

3. Wood, Austin: Personal communication to the authors.

During the past few years we have had an opportunity to observe a series of cases in which definite pathologic changes could be demonstrated clinically, in all of which there was a history of more or less severe injury to the kidney at a previous time, and the late results of the injuries in many of our cases have been of such a serious nature that it has seemed advisable to emphasize this aspect of the problem. After a consideration of the series of cases which has been studied, it would seem that at least some of the serious after-effects which have been observed might have been prevented by better surgical methods, instituted either shortly after the injury had been received or at a later period, when the patient's general condition would permit of more active methods.

The tendency toward conservatism in the treatment of injuries of the kidney can be readily understood, and there is no doubt that in many of the cases of less severe injury expectant treatment may be the best choice and may not be followed by any appreciable damage to the kidney and its surrounding structure which can be demonstrated at a later date. The surgeon who attends the patient is preoccupied at first by combating the shock, which is usually present, and if he is successful in tiding the patient over this critical period and avoiding operative intervention it is only natural, as the patient's condition improves and signs of active bleeding have ceased, that he should consider that he has successfully brought the patient through the crisis and that by his judgment an operation has been avoided. Also, from the patient's standpoint it is difficult to understand why, some time after he has been carried through the stage of acute injury, when he may feel himself well on the road to convalescence and complete recovery, operative intervention is advised.

To understand the production of persistent changes in the kidney itself or in its surrounding structures, it is necessary to visualize the possible immediate effects of traumatism to the kidney. Küster [4] has studied the mechanics of the problem and by his experiments has demonstrated that the kidney filled with blood may be compared to a body of fluid under hydraulic tension, so that on the reception of an injury the "force exerted upon any part of the fluid is transmitted equally in all directions throughout the mass." The possibility of a crushing injury directed through the kidney against the bodies or transverse processes of the vertebrae and ribs is, of course, self-evident.

For practical consideration, three types of injuries to the kidney may be inflicted which will lead to persistent after-effects.

4. Küster: Zur Entstehung der subcutan Nierenzerreissungen und der Wanderniere, Arch. f. klin. Chir. **50**:676-686, 1895.

(*a*) Injuries to the cortex, with rupture of the true capsule, in which more or less extensive extravasation of blood and urine may occur in the perirenal tissues. While undoubtedly small extravasations may be readily and completely absorbed, in cases of more extensive involvement the hematoma thus formed is of such an extent that it will not resolve and will become encysted in time. The precipitation of the calcium in the blood clots, often combined to some extent at least with the urinary salts, may lead to thickening and calcification in the wall of the cyst. The size of the cyst and its adherence to contiguous structures may lead to grave disability. The destruction of renal parenchyma may lead to permanent loss of function. The presence of a calcified cyst closely adherent to the capsule of the kidney may lead to further reduction of function through pressure atrophy.

(*b*) The parenchyma of the kidney may be torn into the calices or pelvis. In healing, the calices or pelvis may be greatly distorted by scar tissue, eventually causing hydronephrosis, dilatation and distortion or even obliteration of a calix, and during the period when the pelvis is distended with a blood clot and hence draining poorly, urinary salts may be deposited on a portion of the clot and lead to calculus formation. In this type of injury again considerable distortion by scar tissue may result with subsequent permanent diminution of function.

(*c*) Injuries to the pelvis, or especially the upper portion of the ureter. If the tear is incomplete, subsequent cicatrization may lead to obstruction and hydronephrosis. If the ureter is completely torn across at the time of the injury, the kidney will eventually be completely destroyed. However, there will probably be an extensive peripelvic extravasation of blood and urine.

Figure 1 (from Osgood and Campbell) will help to visualize the main types of injury to the kidney which may be inflicted, but two additional diagrams should be included: one to show injuries of the vascular pedicle and the other to show injuries of the pelvis and ureter. In *A* (fig. 1) tears have been inflicted in the parenchyma with rupture of the true capsule and little or no extravasation. Such an injury might, in all probability, heal cleanly without demonstrable after-effects, provided that the pelvis or calices had not been too badly torn. In *B* multiple complete ruptures of the kidney have been inflicted, and one would expect perirenal extravasation. If the patient did not die of immediate hemorrhage and if operation were not undertaken, the kidney would be completely destroyed and would finally be represented by an atrophic mass of scar tissue enclosed in a cyst, the wall of which would later become calcified. In *C* the cortex and capsule have been ruptured, but the injury has not extended into the pelvis or calices. In case of such an injury bleeding would probably stop when compression

from the perirenal hematoma reached an appreciable degree. The injury of the renal cortex would probably heal with a minimal formation of scar tissue. If the perirenal hematoma were very extensive, it would probably result ultimately in the formation of a calcified cyst adherent to the kidney and distortion of this structure by pressure. In *D* the capsule and parenchyma of the kidney have been ruptured into the pelvis. Here again a perirenal hematoma would be formed, which might result in a persistent calcified cyst. The pelvis has been torn and during the cicatrization might lead to extensive distortion by scar tissue with resulting hydronephrosis. In addition, urinary salts might deposit on the blood clot present and lead to renal calculus. In *E* the parenchyma

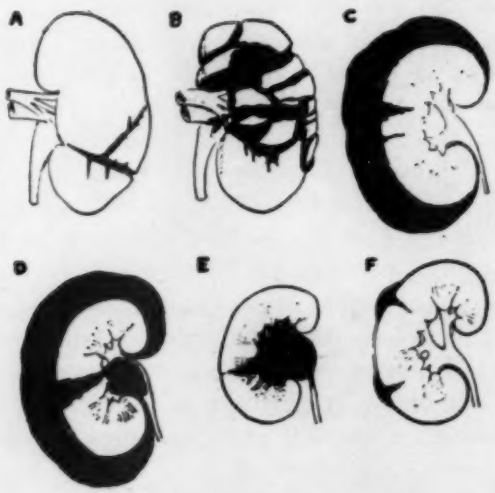

Fig. 1.—The common types of traumatic injury of the kidneys. Reproduced from Osgood and Campbell, in Lewis, D.: Practice of Surgery, Hagerstown, Md., W. F. Prior Compnay, Inc., 1929, vol. 8, chap. 5.

has been torn into the pelvis. The true capsule has not been ruptured, and there will be no perirenal hematoma. In case of this type of injury also the pelvis might be distorted by the subsequent formation of scar tissue, and there is a possibility of the formation of a stone. In *F* two ruptures have been inflicted in the cortex, but the true capsule has not been torn. The after-effect of such an injury would probably be minimal, and extravasation under the unruptured capsule would in all probability produce so much pressure that the bleeding from the tear in the cortex would soon stop. Such an extravasation would probably be easily reabsorbed. There is a possibility that a small cyst might persist.

Tearing injuries of the vascular pedicle usually result in death from hemorrhage. If the patient should survive such an injury, the kidney would of course be necrotic and surrounded by a large perirenal hematoma. Ruptures of a previously normal pelvis would be extremely rare, and it is difficult to understand how such an injury could be received without extensive damage to the kidney. However, in cases of primary hydronephrosis, rupture of the distended pelvis has been frequently reported. Such an injury would lead to extravasation of urine, mostly about the kidney, and the resulting scar tissue would probably further distort the hydronephrosis and hasten eventual complete destruction of the kidney. The ureteral wall may be crushed to such an extent that subsequent cicatrization will lead to traumatic stricture and hydronephrosis. In such cases there would be little or no perirenal hematoma unless the renal cortex had been injured and its capsule torn. Should the ureter be completely severed, there will result a perirenal extravasation of urine, and of course subsequent cicatrization will result in complete destruction of the kidney.

Infection may complicate the picture at any time in any one of these injuries. Should a perirenal hematoma become infected, it will take on the characteristics of a perirenal abscess. The clotted blood is an excellent medium for the growth of micro-organisms, and the injury of the tissue through trauma or from the extravasation of urine would further enhance the virulence of the infection. If infection should supervene either through the blood stream or through a ureteral catheter in a pelvis which has been torn and is filled with a blood clot, pyonephrosis with complete destruction of the kidney may easily develop or the infection may simply tend further to distort and complicate formation of scar tissue.

Distortion of the pelvis or calices will favor the persistence of infection. On account of the interference with drainage and the production of dilated cavities, the changes in the wall of the pelvis or calices due to scar tissue resulting from the injury may also interfere with the natural resistant properties of the tissues.

Eisendrath [5] recently reported a case of stricture at the ureteropelvic junction with resulting hydronephrosis, which he attributed to an accident twenty years previously, which was followed by severe pain and hematuria of two weeks' duration. The patient was treated conservatively, and the symptoms disappeared. Eisendrath saw the patient after the kidney was transformed into a hydronephrotic sac, as a result either of direct injury to the ureter or of contracture of periureteral scar tissue.

5. Eisendrath, D. N.: Ureteral Stricture and Hydronephrosis as Late Sequel to Kidney Injury, J. A. M. A. **104**:1898-1899 (May 25) 1935.

The importance of recognition of a perirenal hematoma after injury to the kidney is suspected has been emphasized by Warner.[6] Hagner advised expectant treatment in cases of injury to the kidney if the hemorrhage is diminishing in amount and there is no evident perirenal extravasation.

Kemm[7] reported a most unusual case which illustrates the necessity of continuous observation in cases in which injury to the kidney is suspected, even though clinical improvement may proceed uneventfully. His patient suffered a severe crushing injury to the left lumbar region. Shock lasted for twenty-four hours, and the patient was discharged from the hospital on the sixth day. He was readmitted ten days later in good condition, but with marked swelling of the abdomen, which on examination was found to be due to a tightly encapsulated collection of fluid extending from the diaphragm to the pelvis on the left side. At operation about 2 liters of straw-colored fluid was found surrounding the kidney, which had been completely divided at the junction of the upper and the middle third. The history in this case is similar to that in cases 5, 6, 8 and 10 of our series, in which abdominal swelling was noted some time subsequent to the accident. Had operation not been performed, undoubtedly a large calcified cyst would have resulted.

The effect of infection on the subsequent course in such cases has been emphasized by many writers. Infection of a perirenal hematoma is a serious complication and may lead to extension of the abscess thus formed in many directions along the lines of least resistance. Infection directly introduced into the kidney, as in the case reported by Jeck,[8] is extremely dangerous, as the devitalized tissue resulting from the injury forms an excellent medium for the growth of organisms. Culver[9] advised against early ureteral catheterization in dealing with injury to the kidney on account of the danger of introducing infection, but when pain persists after spontaneous recovery he advised that pyelography be carried out to determine whether distortion of the pelvis and calices is present. Woodruff[10] expressed the belief that the subsequent loss of functional ability depends on the type of obstruction of

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6. Warner, F.: Traumatic Injuries of the Kidney, Boston M. & S. J. **176**: 740 (May 24) 1917.

7. Kemm, N.: Rupture of the Kidney: Delayed Symptoms; Operation; Recovery, Brit. M. J. **2**:1218 (Dec. 22) 1923.

8. Jeck, J. S.: Stab Wound of Kidney: Unusual Complication, J. Urol. **17**: 449-452 (April) 1927.

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the organ and particularly on infection. He stated that a study of those patients not subjected to nephrectomy who have recovered without the intervention of infection would surely prove that in ordinary cases of rupture of a kidney by far the major number of patients recover without any appreciable diminution in functional ability. If infection involves the parenchyma, pyelonephritis, pyonephrosis and renal calculus may develop. Backus [11] reported a case of severe injury to the right lumbar region, followed by shock and hematuria. The patient recovered under expectant treatment, and pyelograms taken one month and two months after the injury showed the gradual development of hydronephrosis with contracture at the ureteropelvic junction, which he interpreted as a posttraumatic fibrosis. West [12] stated that after three or four days of conservative treatment in cases in which hematuria persists with tumefaction in the left lumbar region, exploratory operation should be done without further delay, in an effort to control the hemorrhage and prevent infection.

Beretervide [13] expressed the belief that thickening of the capsule of the kidney associated with pain and diminution of renal function, the syndrome known as nephrosclerosis, occurs as a result of trauma. He reported the case of a man aged 53 who received a severe injury in the right lumbar region, with hematuria persisting for twenty days and pain in the injured side on walking and effort, which persisted for a year and a half. Ureteral catheterization showed marked diminution in the function of the right kidney. Beretervide emphasized the significance of this condition in the work of an industrial accident commission.

In the literature there are a few reports of the development of renal calculus after injury to the kidney. Boshamer emphasized the importance of posttraumatic calculus and mentioned the fact that this condition is rarely mentioned in textbooks. He expressed the belief that a stone may form by deposition of urinary salts on a clot or about a piece of necrosed tissue. If associated injuries to the spine or long bones are present, the probability of the formation of a stone is enhanced, as has been observed in injuries of this type. Dubner [14]

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11. Backus, H. S.: Traumatic Rupture of Kidney with Symptomatology of Acute Abdomen, with Case Reports, New England J. Med. **211**:563-564 (Sept. 27) 1934.

12. West, L. A.: Traumatic Rupture of the Kidney, J. Iowa State M. Soc. **25**:90-92 (Feb.) 1935.

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expressed the belief that in every true traumatic renal calculus a nucleus of blood coagulum should be demonstrable in the concrement. He emphasized the fact that renal calculi occur frequently in cases of traumatic transverse lesions of the spinal cord, but quite correctly he did not regard them as true traumatic renal calculi. He reported the case of a patient aged 18 who received a severe injury to the left flank. No definite history of hematuria could be obtained. Two years later the patient began to have severe pains in the left lumbar region at irregular intervals. Roentgen examinations at this time revealed no calculi, but on microscopic examination blood was seen in the urine. The pains continued at intervals, and a year later roentgenograms revealed a calculus in the region of the right renal pelvis. The calculus was removed through a pyelotomy incision, and the specimen consisted of two flat shells of calcification, inside of which an old blood clot was situated.

Bonar [15] reported two cases of retroperitoneal hemorrhage. He described the case of a woman aged 30 whose left eye had been removed for "tubercular trouble" several years previously. She noticed pain in the right loin followed by a swelling on this side of the abdomen five months after a fall. At the time of the original accident she was not severely injured, and no hematuria had occurred. An exploratory laparotomy was done, and it was discovered that a large retroperitoneal hemorrhage had occurred following the trauma. A tumor was later found at the same site. In reviewing this case, however, it seems more probable that the melanotic sarcoma was secondary to a tumor of the eye and that the retroperitoneal hemorrhage occurred spontaneously from extension of the tumor through the capsule and bore no relation to the trauma which had occurred five months previously.

In the following series of cases, a short summary of each of which is given, definite pathologic changes could be demonstrated either on clinical examination or at operation which were definitely correlated to a previous injury to the kidney.

REPORT OF CASES

CASE 1.—A. H., aged 13 years, was admitted to the hospital on July 25, 1933, a few hours after the right side was injured by a fall from a horse. Hematuria persisted for ten days and severe pain for the first few days. The patient was discharged on August 10, free from symptoms and with the urine clear. An intravenous urogram made four months later (November 6) showed hydronephrosis of the upper calices and marked distortion of the lower calix (fig. 2*A*).

A rupture through the kidney substance, probably into the pelvis, resulted from the accident, and in the process of the formation of scar

15. Bonar, T. D. G.: Two Cases of Retroperitoneal Hemorrhage, Lancet **1**: **25**:90-92 (Feb.) 1935.

tissue, there was distortion of the pelvis and calices. While the patient is free from symptoms at present, it is probable that the hydronephrosis will progress and the formation of a stone is a distinct possibility.

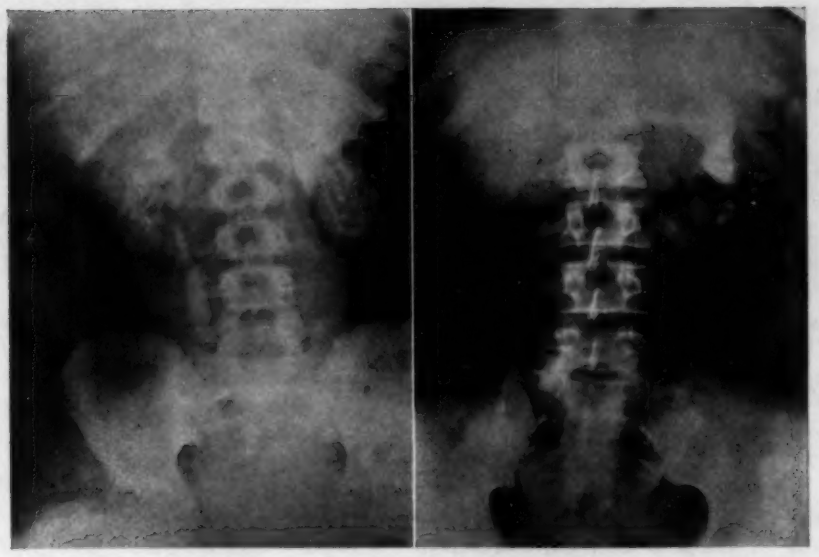
CASE 2.—L. M., aged 27, was admitted to the hospital on Oct. 4, 1929, complaining of dull pain in the left side and cloudy urine. His left side was injured fifteen years previously by a fall. He had severe pain for three days and hematuria for ten days. A plain roentgenogram (fig. 2 *B*) showed a large stone filling the upper portion of the left kidney and numerous small stones in the lower calix. Ureteral catheterization showed marked diminution of function of the left kidney. A pyelogram (fig. 3 *A*) showed marked hydronephrosis and especially distortion of the upper calix. On account of the presence of stone, the reduction in function and the markedly distorted pelvis, nephrectomy was done on November 8.

The stone almost certainly arose as a result of the injury to the kidney. It seems possible that had the kidney been exposed at the time of the accident, with repair of the injury and especially drainage of the pelvis by nephrostomy, the extensive distortion which later necessitated nephrectomy might have been avoided.

CASE 3.—A. R., aged 55, was admitted to the hospital in October 1929 on account of attacks of pain in the left lumbar region. The patient had received a severe injury to the left lumbar region in a motor boat accident six years previously. Hematuria appeared after the accident and persisted for three weeks. One year later calculus was removed through a nephrotomy incision. A roentgenogram (fig. 3 *B*) showed a small stone in the lower calix, and a pyelogram showed definite constriction at the ureteropelvic junction, with early hydronephrosis.

It seems possible that had the kidney been exposed after the accident and the pelvis washed free from blood clots and adequately drained, the subsequent formation of a stone and operation might have been prevented. The stone which is now present will probably grow steadily and necessitate another operation, possibly nephrectomy. The stricture at the ureteropelvic junction, demonstrated by pyelographic study, was probably caused by the formation of scar tissue resulting either from direct injury or from perirenal hemorrhage.

CASE 4.—D. C. entered the hospital on April 7, 1936, on account of recurrent attacks of severe pain in the left lumbar region. He fell from a tree in September 1934, injuring the left lumbar region. He suffered pain for a few days, and blood was present in the urine for three weeks. A pyelogram (fig. 4 *A*) showed an enormous hydronephrosis, with marked distortion and incomplete filling. On account of the fact that the kidney was functionless, nephrectomy was done. The operative specimen (fig. 4 *B*) showed an enormous hydronephrosis, with almost complete destruction of secreting tissue. Marked kinking and obstruction were demonstrable at the ureteropelvic junction. On both the external and the internal aspects of the pelvis there was a large well healed puckered scar. It seems probable that a symptomless primary hydronephrosis was present at the time of the accident, as a result of which the wall of the distended pelvis was ruptured. It would be difficult to conceive of such an injury to a normal pelvis without extensive destruction of the lower pole or midportion of the kidney.



A B

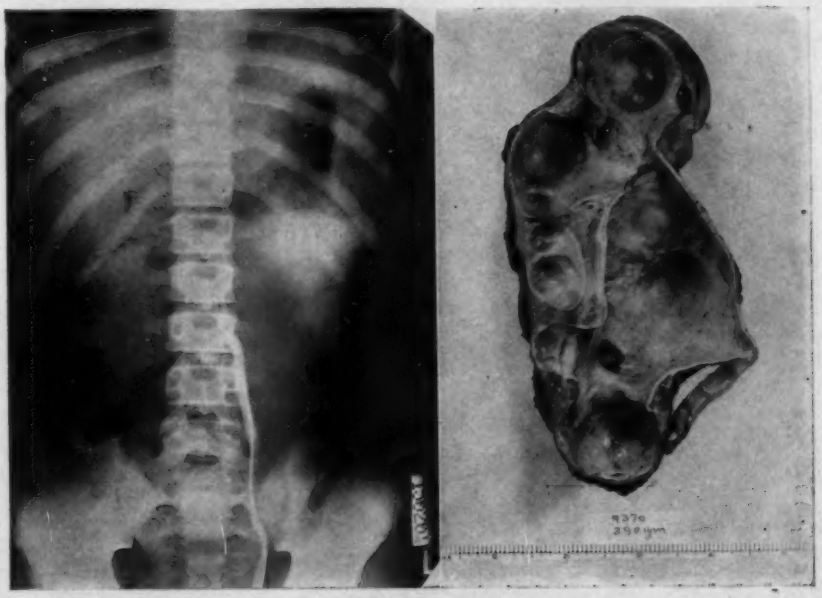
Fig. 2.—*A*, an intravenous urogram made four months after the accident in case 1. There are moderate dilatation of the upper and the middle calix of the right kidney and marked distortion and irregularity of the lower calix. *B*, a plain roentgenogram made in case 2, showing a large stone filling a portion of the pelvis and a greatly dilated upper calix. Numerous small stones are present in the middle and lower calix.

A B

Fig. 3.—*A*, a pyelogram showing a large dilatation and distortion of the upper calix with moderate dilatation and clubbing of the middle and the lower calix in case 2. The pelvis and upper portion of the ureter are moderately dilated. *B*, a roentgenogram showing a small stone apparently in the lower calix of the left kidney in case 3.

If exploration had been made in this case soon after the injury, it might have been possible to repair the tear in the pelvis and correct the obstruction at the ureteropelvic junction by an appropriate plastic procedure and, with the institution of drainage, to save the kidney. It would have depended, however, on the findings at exploration and on the amount of undamaged kidney tissue which was present.

CASE 5.—S. R. T., a patient of Dr. Hugh H. Young, was admitted to the hospital in March 1924, at which time a diagnosis of tuberculosis of the seminal tract was made. A radical excision of the seminal tract was done by Dr. Young. The patient was seen again in April 1926, in excellent condition, with the incision well healed. He complained of a dull pain in the region of the left kidney. On further questioning at this time it was brought out that thirty years previously



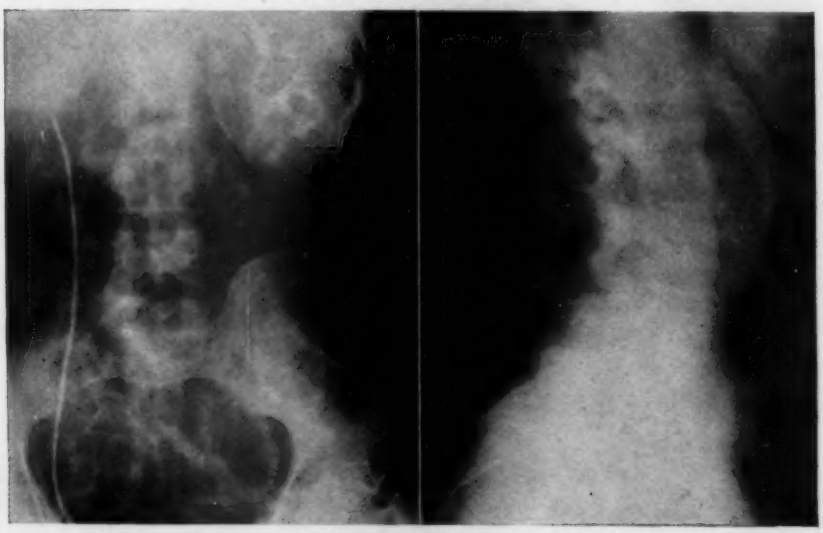
A B

Fig. 4 (case 4).—*A*, a retrograde pyelogram showing marked dilatation and incomplete filling of the pelvis of the left kidney. The upper portion of the ureter is also dilated and is pushed toward the midline. *B*, operative specimen. The secreting tissue of the left kidney has been practically completely destroyed by hydronephrosis. The pelvis is markedly dilated, and an old puckered scar is present on its internal and external surfaces. There are marked kinking and definite obstruction at the ureteropelvic junction.

he had been run over by a wagon, the wheels passing over the left side. He did not remember the presence of blood in the urine, but a gradual swelling of the abdomen occurred, becoming so prominent that six months later a large amount of fluid was drawn out by a needle on two occasions. For the past few years he had noted a dull pain in the left side of the abdomen and left lumbar region. A stereoscopic roentgenogram showed a large calcified cyst over the left

kidney, apparently closely adherent to its anterior surface. Cystoscopic examination, ureteral catherization and pyelograms (fig. 5) showed no evidence of renal disease. The kidney was exposed through an extraperitoneal incision by Dr. Young, and a large calcified cyst was found adherent to a scar on the anterior surface of the kidney. On account of the dense scar tissue which bound the cyst to the peritoneum and intraperitoneal viscera, excision was impossible.

It seems probable that the extensive rupture of the kidney occurred at the time of the accident, with resulting perirenal extravasation. A large portion of the fluid resulting from the perirenal extravasation was subsequently removed by tapping, but the walls of the remaining portions of the hematoma became calcified as a result of the changes which took place in the disintegrated blood clot.



A B

Fig. 5 (case 5).—*A*, a stereoscopic pyelogram of the left kidney. The pelvis is well filled. The calices are cup shaped and normal. No dilatation or other abnormality of the pelvis is seen. The cyst can be seen lying in front of and in close approximation to the kidney. *B*, a lateral pyelogram showing the close approximation of the cyst to the anterior surface of the kidney.

Case 6.—H. B., a patient of Dr. A. E. Goldstein, was admitted to the Sinai Hospital in February 1926, on account of disability from a large mass in the right side of the abdomen. Twenty-five years previously the patient had been kicked by a horse in the right flank. He was rendered unconscious for some hours and did not remember whether blood was present in the urine. Several days later a mass appeared in the right flank, which slowly increased in size. For the past six months it had caused great discomfort and incapacity. A plain roentgenogram (fig. 6) showed an enormous multilocular calcified cyst occupying the entire right half of the abdominal cavity and extending down below the brim of the

pelvis. On account of the extreme disability and pain, an attempt to remove the cyst was made. The operative procedure resulted in shock, from which the patient failed to rally.

It is evident that had operation been carried out at a time after injury when the patient's condition would permit, the extravasation could have been drained and the blood clot removed and the subsequent formation of this enormous multilocular cyst could have been prevented.

Case 7.—G. K., aged 38, a patient of Dr. Hugh H. Young, entered the hospital in October 1923 on account of dull pain in the region of the right kidney. Four years previously he had been severely injured about the back and head in an automobile accident. His injuries necessitated hospitalization for several months, during the first few weeks of which blood was present in the urine.

Fig. 6 (case 6).—A plain roentgenogram showing a large multilocular calcified cyst occupying the entire right side of the abdominal cavity.

A stereoscopic roentgenogram (fig. 7) showed a large calcified cyst intimately attached to the anterior surface of the right kidney. On account of the fact that the cyst was causing no severe disability and on account of the technical difficulties encountered in the previous case, no treatment was advised.

If the kidney had been explored after the accident at a time when the patient's general condition was satisfactory, the perirenal clots could have been evacuated with drainage, and the subsequent formation of the cyst would have been prevented.

Case 8.—S. M. S., aged 21, a patient of Dr. Hugh H. Young, was admitted to the hospital in March 1929 on account of a mass in the left side of the abdomen and numbness of the left leg. Twenty-one years previously he had

been struck in the left side by a sled and was rendered unconscious for a few hours and confined to bed for several weeks, but he did not remember that blood was present in the urine. A large mass gradually developed in the left side of the abdomen, and two and a half years before admission a large amount of fluid was withdrawn by aspiration. A stereoscopic roentgenogram (fig. 8*A*) showed a huge multilocular cyst occupying the entire left side of the abdomen and causing marked scoliosis. Ureteral catheterization showed no function from the left kidney, and on pyelography it was impossible to introduce the medium into the pelvis. It was evident that the left kidney had been completely destroyed. On account of the extreme difficulty and pain caused by the cyst, it was exposed extraperitoneally by Dr. Young. As much of the walls as possible was excised, the remaining portions of the walls were crushed in and drainage was instituted in such a manner as to marsupialize the remainder of the cavity (fig. 8*B*).

The kidney probably suffered a comminuted injury at the time of the accident, resulting in enormous perirenal extravasation and sub-

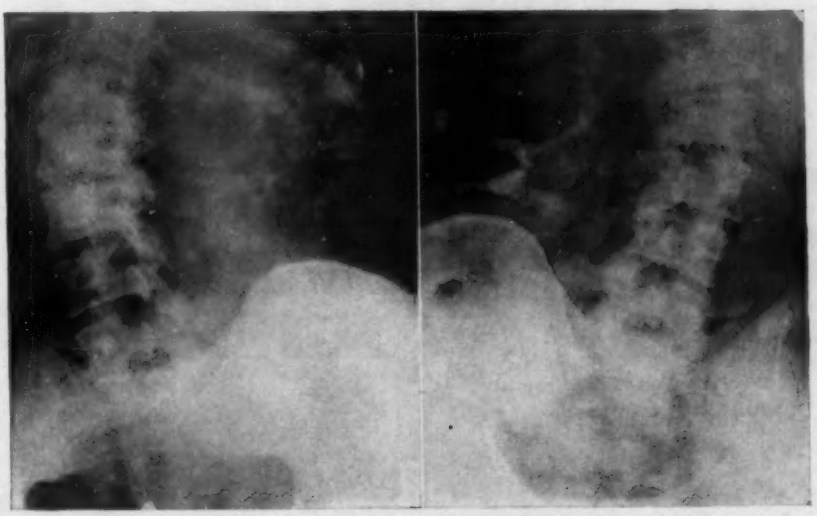
Fig. 7 (case 7).—A stereoscopic pyelogram of the right kidney. The pelvis is well filled, the calices are normal, and there is no dilatation or other abnormality of the pelvis. A cyst is seen to lie in close approximation to the anterior surface and convex border of the kidney.

sequent complete destruction of all renal tissue. The consequent formation of a cyst could have been prevented by exposure of the kidney after the accident. It is probable that the kidney would have been found so badly injured that nephrectomy would have been necessary, but this procedure, followed by evacuation of perirenal clots and institution of adequate drainage, would have prevented the subsequent formation of this huge cyst.

Case 9.—J. S., aged 63, a patient of Dr. Hugh H. Young, entered the hospital in October 1930 on account of obstruction to urination. A cautery punch was done with complete relief from symptoms. The patient returned to the hospital in February 1931, complaining of a burning sensation in the hip. On

further questioning it was brought out that two years previously he had fallen from a scaffold and had received a severe injury across the back. He was unconscious for a short time and was incapacitated for four weeks, but at no time was there any blood in the urine. A stereoscopic roentgenogram (fig. 9) showed a small calcified cyst attached to the upper pole of the right kidney. On account of the absence of symptoms, no treatment was advised.

It seems safe to infer from the history that a cortical rupture of the upper pole of the kidney not involving the pelvis was incurred at the time of the accident, and the comparatively small extravasation of blood resulted subsequently in the formation of a small calcified cyst. It is evident that a cortical injury tearing through the capsule, but not



A B

Fig. 8 (case 8).—*A*, a stereoscopic roentgenogram showing a large calcified cyst with irregular margins occupying the entire left side of the abdomen. Only at the upper left border can the cyst margin be definitely made out. The calcification in this case is not so pronounced as in the preceding instances. The size of the cyst caused marked scoliosis. *B*, postero-anterior view taken twenty months after the operation. The outlines of the cyst can no longer be made out. Indefinite calcification is seen in the left side of the abdomen, with marked accentuation of calcification in linear areas as if there had been approximation of the walls of the cyst with intensification of the shadow.

involving the pelvis, might not be accompanied by hematuria, but the resulting extravasation might later lead to the formation of a calcified cyst.

Case 10.—J. C., aged 21, was seen by Dr. C. A. Waters at the United States Marine Hospital, Baltimore, on account of abdominal pain and symptoms refer-

able to the gastro-intestinal tract. Fifteen years previously the patient was struck by an automobile and severely injured. Exploratory laparotomy was done on the day of the accident, but no injury of abdominal viscera was found, and there was no free blood in the peritoneal cavity. The patient did not remember whether blood was present in the urine. He made an uneventful recovery from the operation, but subsequently a large mass became palpable in the right side of the abdomen. A stereoscopic roentgenogram (fig. 10) showed a large calcified cyst closely adherent to the right kidney.

The patient's general condition at the time of the laparotomy apparently did not permit of careful examination of the region of the kidney. If the presence of a perirenal hematoma had been discovered, evacuation of the blood clots through a lumbar incision and adequate drainage would have prevented the development of this cyst.

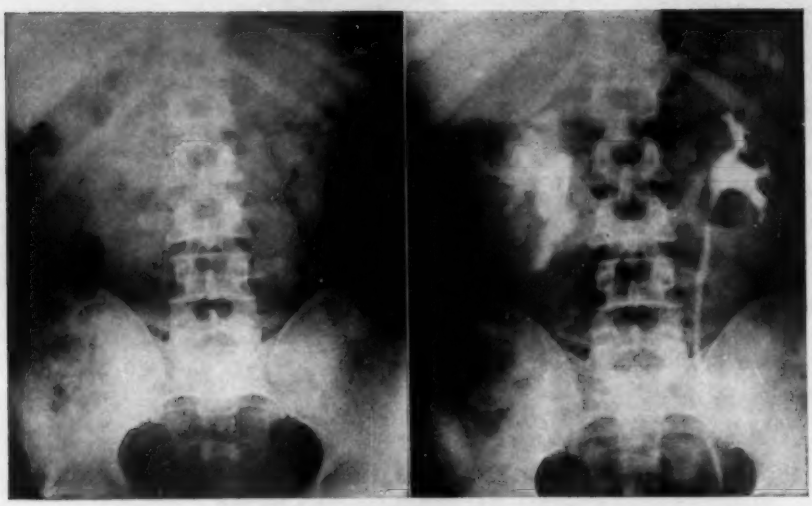
Fig. 9 (case 9).—A stereoscopic roentgenogram showing a small calcified cyst with well defined margins lying in proximity to the upper pole and the convex border of the right kidney.

Case 11.—S., a patient of Dr. Austin Wood, was admitted to the hospital on May 25, 1935, on account of severe pain in the right lumbar region. On April 26 he was thrown from an automobile and received a severe blow in the right side of the epigastrium. He suffered severe pain but was able to walk home. Fresh blood was noted in the urine and persisted for three days, gradually clearing. On May 8 the pain had almost completely disappeared, and the urine was only faintly blood tinged. Physical examination revealed an indefinite sense of resistance over the right kidney, with tenderness, but no definite mass was felt. The urine contained masses of red cells but no organisms. A plain roentgenogram (fig. 11 *A*) showed complete obliteration of the outline of the right kidney and obliteration of the shadow of the psoas muscle. On cystoscopic examination smoky urine could be seen coming from the right ureter. A no. 6 catheter was introduced a short distance up the right ureter, and a pyelogram (fig. 11 *B*) showed marked distortion of the pelvis and obliteration of the calices. An

indefinite shadow extending toward the cortex suggested perirenal extravasation. The pelvis was markedly dilated, and there was probably extravasation around the upper portion of the ureter and the lower pole of the kidney. On account of the definite severe injury to the kidney, immediate operation was advised, but the patient refused to enter the hospital. His condition continued to improve, and the pain disappeared; he resumed his duties as a traffic policeman. On May 25 he was admitted to the hospital in shock, suffering severe pain in the right lumbar region, and the urine was grossly bloody. At operation by Dr. Wood a complete rupture of the kidney was found (fig. 12) at about the junction of the upper and the middle third with extensive comminution. An extensive perirenal clot was found, and active fresh bleeding was encountered, probably coming from the torn vascular pedicle. The clots were evacuated, the pedicle ligated and the kidney removed.

Fig. 10 (case 10).—A stereoscopic roentgenogram showing a large clearly outlined calcified cyst occupying the whole right side of the abdominal cavity. The typical irregular calcification is much more pronounced in the upper portion of the cyst.

It was evident from the plain roentgenogram that an extravasation of considerable degree was present about the right kidney. The pyelogram showed that an extensive comminuted injury of the kidney had been inflicted. Many writers have questioned the advisability of using retrograde pyelography in questionable cases of injury to the kidney on account of the possibility of stirring up bleeding or especially of introducing infection. However, in this case no immediate reaction occurred, and valuable information was obtained as to the extent of the damage done, so that there was no question as to the advisability of prompt operation. Had the patient consented to operation at this



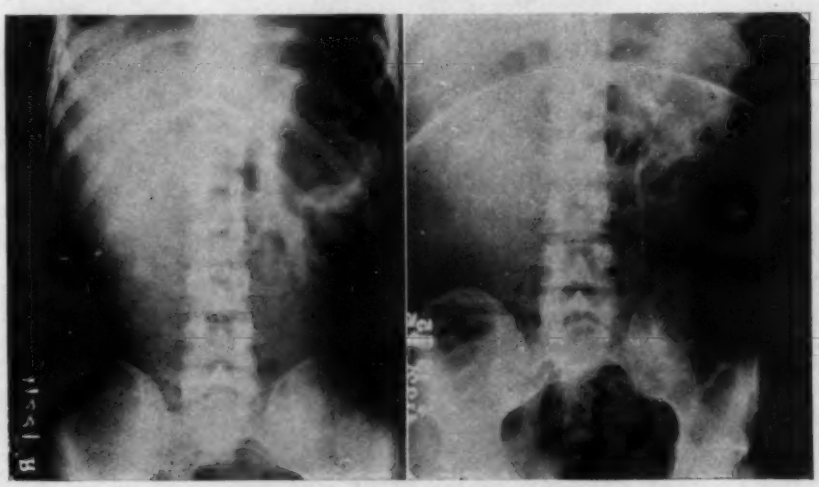
A B

Fig. 11 (case 11).—*A*, a plain roentgenogram showing complete obliteration of the outline of the right kidney and obliteration of the shadow of the psoas muscle. *B*, a pyelogram showing marked distortion of the pelvis with obliteration of the normal shadows of the calices. Apparently there has been extravasation of the pyelographic medium through a transverse rupture at the junction of the upper and middle third of the kidney. There is a large hematoma under the capsule, surrounding the lower pole of the kidney. The pelvis is markedly dilated and distorted, and there is apparently some extravasation of the opaque medium at the region of the ureteropelvic junction.

Fig. 12 (case 11).—Operative specimen showing two complete ruptures through the kidney.

time, his general condition would have been much better than it was when the operation was actually performed. In addition, it seems probable that the operative procedure would have been much simpler because there would have been little or no fresh bleeding with which to contend.

CASE 12.—K., aged 28, a patient of Dr. Austin Wood, was struck with a piece of pipe in the right lumbar region on March 22, 1935. He suffered pain, and the urine showed gross hematuria. A plain roentgenogram (fig. 13 *A*) showed the shadow of the right kidney and the psoas muscle to be completely obliterated. Immediate operation was advised, but this recommendation was disregarded by the general surgeon, and the patient was treated expectantly. He was readmitted to the hospital on May 13. Examination revealed a large mass filling the entire right side of the abdomen, extending to the iliac crest. An intravenous urogram



A B

Fig. 13 (case 12).—*A*, a plain roentgenogram made immediately after the accident, showing obliteration of the outline of the right kidney and the right psoas muscle. Gas shadows in the region of the left kidney give a fictitious appearance of a pyelogram. *B*, an intravenous urogram made one month after the accident. No dye has been excreted in the right kidney. The outline of the kidney and that of the psoas muscle are still obliterated. The left kidney shows good excretion, and the calices, pelvis and ureter are normal.

(fig. 13 *B*) showed the obliteration of the shadow of the right kidney and the psoas muscle still present. There was no evidence of excretion of the dye by the right kidney. The pelvis of the left kidney was well outlined and appeared normal. Operation was performed by Dr. Wood on May 20. Approximately 1,500 cc. of extravasated blood and urine was evacuated from around the kidney. The organ was ruptured transversely, and the lower pole was completely separated. Nephrectomy was done. Convalescence was uneventful.

CASE 13.—S. M., aged 37, a patient of Dr. Austin Wood, was injured in an automobile accident in 1933. He was treated expectantly by the family physician for a few days, but was then admitted to the hospital on account of hematuria and pain in the right lumbar region. Roentgen examination and intravenous urograms gave no important information. He was treated expectantly for two weeks and then discharged. He was seen by Dr. Wood on March 25, 1935, two years after the accident. He had had continuous dull pain in the right side since the accident, and hematuria had recurred. A plain roentgenogram (fig. 14) showed the outline of the right kidney to be rather indefinite. The kidney seemed somewhat larger than normal, and opposite the transverse process of the second lumbar vertebrae, apparently in the pelvis, was the shadow of a rather large, soft stone, measuring about 4 by 2 cm.

Fig. 14 (case 13).—A plain roentgenogram of the right kidney. The outline of the organ is rather indefinite, but appears larger than normal. Opposite the transverse process of the second lumbar vertebra is a large stone, apparently in the pelvis of the kidney.

SUMMARY

A series of thirteen cases is presented, in all of which clinical examination or operation has revealed definite pathologic changes either in the kidney or in the perirenal tissue. All of these patients had previously been severely injured in the region of the kidney, at varying intervals of time before the patient was seen. The definite relationship of the trauma to the conditions described in these cases has been established, the conditions encountered varying from those causing minimal disability to those causing complete incapacity. In one patient the condition

which arose as a result of the injury to the kidney was sufficient to cause death, and in most cases operation was necessary.

It is not the purpose of this report to condemn conservative treatment of injury to the kidney. However, the surgeon must be completely familiar with what changes may occur in the kidney or perirenal tissue as a late result of the injuries and should take the proper steps to prevent their development. All cases in which injury to the kidney is suspected should be subsequently studied with special reference to the demonstration of persistent perirenal extravasation. It should be easily recognized by a palpable mass, or the obliteration of the outline of the kidney and shadow of the psoas muscle on roentgenologic examination. In all patients in whom hematuria has occurred as a result of an accident, an injury to the pelvis or calices should be suspected, and subsequent pyelographic studies should be carried out to be certain that distortion or particularly obstruction has not occurred as a result of the formation of scar tissue which may lead to subsequent serious damage to the kidney. In the emergency which exists after any suspected injury to the kidney, in addition to the immediate responsibility, the surgeon should keep in mind a clear perspective of the ultimate changes which may result.

TRAUMATIC RUPTURE OF THE THORACIC DUCT WITH BILATERAL CHYLOTHORAX AND CHYLOUS ASCITES

NEW OPERATION; REPORT OF A CASE

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SAN FRANCISCO

The case[1] on which the following study is based appears to be the first instance of chylothorax (bilateral) with associated chylous ascites of traumatic origin to be reported in the literature, although there are on record up to June 1935 forty-six instances of chylothorax of traumatic origin (Lillie and Fox[2]).

REPORT OF CASE

History.—The patient was first seen by me in consultation on Sept. 10, 1933, four months after the onset of the present illness, at which time the essential facts were ascertained. On May 14, while she was riding in an automobile, a collision occurred and the patient sustained various injuries, the main one being a transverse fracture of the middle third of the left humerus. The bone was set, local anesthesia being used, but it did not retain its position. On June 1 the patient was given a general anesthetic, and the fracture was fastened with pins. This was unsatisfactory and produced neuritis, and on June 5, again with the patient under general anesthesia, the fracture was wired in good position, and roentgenograms taken subsequently showed callus formation. On July 1 the patient complained that the body cast which supported the arm felt tight. At various times portions of this cast were removed. On July 20 fever and malaise developed, and the patient was thought to have influenza. On July 26, fluid was found in the abdomen, and three days later the abdomen was tremendously distended. Roentgenograms taken at this time showed nothing but fluid in the abdomen and an enlarged lymph node in the right hilus. The abdomen was opened on July 29, and a large quantity of nonodorous gray chylelike fluid was expressed. The omentum was devoid of fat, and the pancreas was found to be nodular. No tubercles were seen. The diagnosis at the time was "fat necrosis from a lesion of the pancreas." A bit of pancreas was obtained which on pathologic examination showed no difference from the normal except for fibrosis. During all this time the patient had no abdominal pain except from distention. She recovered satisfactorily from the operation, and the wound was allowed to heal by first intention except for a

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1. A brief report of this same case was published by George J. Heppner: Bilateral Chylothorax and Chyloperitoneum, J. A. M. A. **102**:1294 (April 21) 1934.

2. Lillie, O. R., and Fox, G. W.: Traumatic Intrathoracic Rupture of the Thoracic Duct with Chylothorax, Ann. Surg. **101**:1367-1376 (June) 1935.

small drain. Ten days later all drains were removed, and the temperature subsided to 99.4 F. Seventeen days postoperatively the patient became dyspneic and complained of being unable to sleep. Fluid was found at the base of both lungs. The pulse and respiratory rates were both elevated, but the temperature was essentially normal. The chest was tapped repeatedly on alternate sides. The fluid obtained was determined to be chyle, and the feeding of the fluid by mouth brought about marked but only temporary improvement. The abdomen again became markedly distended, and on tapping 2 liters of chyle was removed from the peritoneal cavity. Repeated thoracentesis was then required to relieve the respiratory embarrassment.

I now saw the patient in consultation with other physicians, and all agreed that bilateral chylothorax and chylous ascites were present. The problems were to determine (1) what could be done and (2) how the condition arose. A review of all the roentgenograms showed fluid in both the abdomen and the chest (fig. 1),

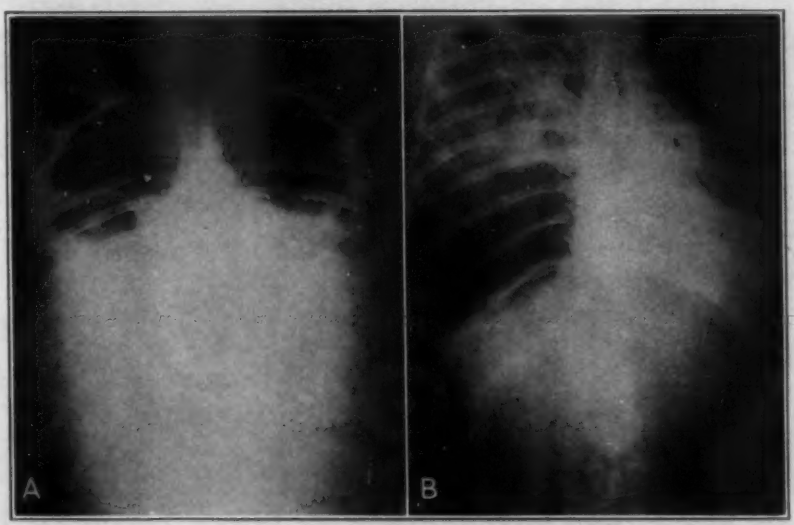

Fig. 1.—*A*, late roentgenogram showing fluid (chyle) in both pleural cavities and the abdomen. *B*, late roentgenogram showing fluid in both pleural cavities and the abdomen and partial collapse of the lungs.

and a roentgenogram (fig. 2) taken ten weeks after the accident showed a rounded shadow of increased density just above the diaphragm and to the right of the spine and the border of the right side of the heart.

Comment.—Chyle is believed [3] to occur outside of the normal chyle ducts and channels either when there is a direct break in the continuity of the duct, as from rupture, or when pressure from without obstructs the passage of fluid through the duct. In the latter instance it is surmised that the fine capillaries distal to the obstruction themselves rupture because of back pressure and allow the chyle to extravasate.

The question now arose as to which process had allowed the chyle to escape in this particular patient. In order to determine if the mass noted in figure 2 *A*

3. Heuer, G. J., in Nelson Loose-Leaf Living Surgery, New York, Thomas Nelson & Sons, 1929, vol. 4, p. 443.

was primarily in the chest or was a herniation of a viscus from the abdominal cavity, pneumoperitoneum was done (fig. 3). This showed no evidence of a hernia, the entire space between the liver and the diaphragm being entirely free.

A study of the literature revealed that in other instances of chylothorax of traumatic origin a cystic mass has been observed in the region of the rupture of the duct and that this mass appeared to communicate directly with the pleural cavity. An example of this is found in the description of the condition found at autopsy in the case of Macnab and Scarlett: [4]

"The lower third of the pleural space was occupied by a well defined cavity which extended to the vertebral column posteriorly and was continuous with the posterior mediastinum. A smaller cavity, about the size of a hen's egg, was located over the body of the tenth dorsal vertebra, in the posterior mediastinum, and was connected with the larger cavity. The walls of the main cavity were about one-eighth of an inch in thickness. The cavity contained partially organized material, which was composed of thin white chylous fluid and masses of coagulated

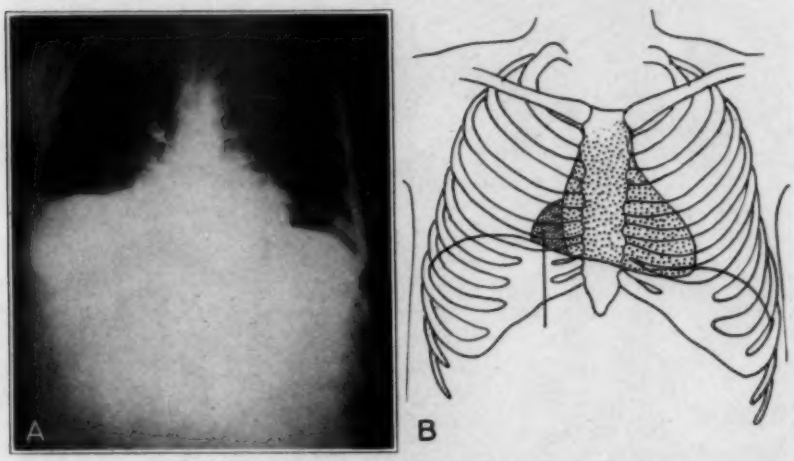

Fig. 2.—*A*, early film showing a rounded mass extending beyond the border of the right side of the heart just above the diaphragm. *B*, a tracing of the x-ray film.

chyle and fibrin resembling large milk curds. Medially, the wall of the cavity was continuous with a mass of low grade inflammatory tissue which occupied the lower third of the posterior mediastinum."

The cases reported previously have a further factor in common with the present case. The accidental force in each instance produced a sudden hyperextension of the spine. It therefore appears possible from anatomic studies that the rupture of the thoracic duct in these instances is brought about by a fixation of that part of the duct which is directly beneath the medial crus of the diaphragm, where in a marked hyperextension of the spine, this firm knifelike edge might so fix on the vertebral body beneath that the duct, being stretched because of the hyperextension, might readily tear or rupture (fig. 4). It was now assumed that this

4. Macnab, D. S., and Scarlett, E. P.: Traumatic Chylothorax Due to Intrathoracic Rupture of the Thoracic Duct, Canad. M. A. J. **27**:29-36 (July) 1932.

had actually occurred in our patient, as the accident, involving a sudden stop to the machine in which the patient was riding, had produced a sudden flexion followed by hyperextension of her spine.

The patient was obviously suffering from the loss of chyle, but in addition there was a marked decrease in the vital capacity owing to the collapse of the lungs from the chylothorax and the pressure of the chylous ascites. Withdrawal of fluid from either the pleural cavities or the abdomen would give only temporary relief, since the chyle reaccumulated rapidly. It was known from the work of Costain and others, who had suggested external drainage of the thoracic duct in cases of sepsis, that with such free external drainage the incision of the duct usually closed spontaneously after a number of weeks or months.

In view of these facts, it was decided to provide external drainage for this patient as a last hope, the expectation being that if it were possible to drain

Fig. 3.—Pneumoperitoneum demonstrates no evidence of herniation of abdominal viscus into the thorax.

directly at the site of the rupture the symptoms due to the fluid in the chest and the abdomen would be alleviated, and the rupture of the thoracic duct might be given an opportunity to heal.

The following operation was then planned and done to provide the most direct means of access to the site of rupture of the duct without entering either the thoracic or the peritoneal cavity (figs. 5, 6 and 7).

Operation and Course.—The patient was placed in the sitting position with the dorsum of the back arched and presenting at one end of the operating table. Paravertebral nerve block, including the tenth, eleventh and twelfth intercostal nerves on the right, and infiltration of the skin with a 0.5 per cent solution of procaine hydrochloride (total 33 cc. used) were carried out.

A vertical incision was made parallel with and 3 cm. to the right of the spinous processes, extending from the level of the tenth rib to the lower border of the first lumbar vertebra. This was deepened by blunt muscle splitting through the paravertebral muscles. The dissection was then further deepened about 1½ inches (3.8 cm.) below the twelfth rib until the body of the first lumbar vertebra was encountered. Separation was carried on between the crus of the diaphragm and the body of the vertebra. The exploring finger encountered a soft mass of tissue, which was found to lie over the anterolateral aspect of the vertebra. This apparently was the direct site of the rupture of the duct. On further dissection this cystic mass was found to communicate directly with the right thoracic cavity.

Fig. 4.—Anatomic dissection showing the edge of the medial crus of the diaphragm with the thoracic duct passing beneath. It is suggested that in hyperextension of the spine this crus fixes the stretched duct at this point and facilitates its rupture.

The exploring finger could be readily moved up along the bodies of the eleventh and twelfth thoracic vertebrae, and the tissues in the posterior mediastinum had a "pulpy" feel. A large soft fenestrated rubber drain was inserted into the posterior mediastinum up to the opening into the right pleural cavity and was fastened in place with silkworm gut sutures. The wound was approximated in layers tightly around the tube. The patient left the operating table in good condition.

The patient withstood the operative procedure, which had been carried out under paravertebral nerve block alone, remarkably well. Unfortunately, however, the following day, while straining at the stool, she suddenly died, the immediate

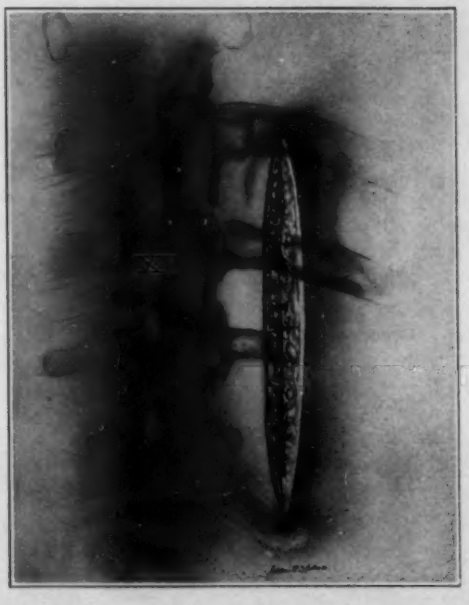

Fig. 5.—Diagrammatic representation of the position of the skin incision with relation to bony landmarks.

Fig. 6.—Operative approach to the area of extravasated chyle as seen when this mass is first observed.

cause of death being shown at autopsy to have been adrenal apoplexy. Autopsy was done by Dr. J. L. Carr, pathologist to the coroner, the following observations being made:

Postmortem Examination.—There was a recent incision, evidently surgical, 5 inches (12.5 cm.) long in the right costovertebral angle, with a rubber drain in it. There were a scar from an old midline abdominal incision 7 inches (17.8 cm.) long and a scar from an old incision 8 inches (20.3 cm.) long over the anterior surface of the right humerus. There were two recent incisions, evidently surgical, each about 1 inch (2.5 cm.) long, in the right antecubital fossa and one about 2 inches (5 cm.) long on the right femur. When the thoracic duct was dissected out an interruption in continuity was found about 2.5 cm. above the diaphragm. There was some fibrosis about the distal end of the broken area apparently occluding the lumen. The proximal end still showed a tiny patent lumen, although there had been some desmoplastic reaction about it.

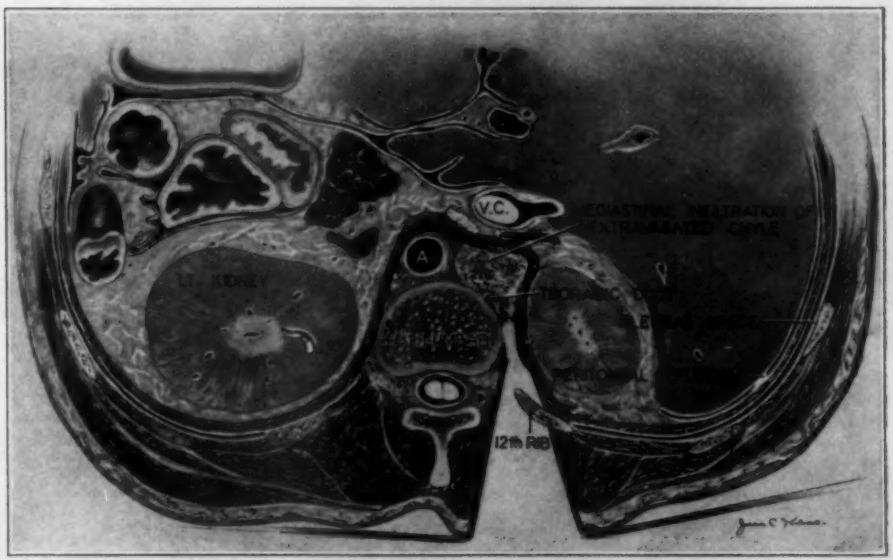

Fig. 7.—Cross-section at the level of the first lumbar vertebra showing (1) location of the extravasated mass of chyle in the mediastinum just above the crus of the diaphragm and (2) the operative incision for drainage of this area without entering either the pleural or the peritoneal cavities.

There was chylous fluid in both the pleural cavities and the peritoneal cavity, that in the pleural cavities being much thinner. All the organs were sent to the pathologist for fixation and examination.

Gross Examination: Specimens were submitted from the heart, lung, liver, spleen, pancreas, kidneys, bowel, uterus and ovaries for study. The heart was very small, weighing 180 Gm. It measured 2½ by 2½ by 4 inches (6.3 by 6.3 by 10 cm.), lay in a clean pericardial sac and had normal vessels and a rather thin and pale but otherwise normal pericardium. The endocardium and valves showed no changes. Both lungs were collapsed and weighed about 225 Gm. apiece. There were massive old adhesions about the base on each side. On the right there was

also a dense succulent mass of adhesions which were at least a month old. A rubber tube ran from this mass out through the right costovertebral angle. The liver was pale and swollen and showed a cloudy swelling of the cells. The capsule was thin, and the edges were blunt. The organ weighed 1,400 Gm. The spleen weighed 60 Gm. and showed a few perisplenic adhesions, moderate thickening of the capsule and rather congested pulp. The pancreas was normal in size, shape and position but was very hard owing to the loss of fat. The adrenal glands weighed about 15 Gm. apiece and showed unusually thick lipoid-filled cortices and fresh hemorrhage occupying the medullary and inner cortical zones. The kidneys showed no significant changes. The uterus, ovaries and tubes were normal except for edema. The intestines showed intense edema, vascular congestion and dilatation of the lacteals.

Histologic Examination: The lungs showed heavy pleural fibrosis. There was partial atelectasis, with many large endothelial cells in the alveolar spaces. The bronchial epithelial cells were desquamated and degenerated. In one area the pleura showed a fibrinopurulent exudate as well as fibrosis. There was a moderate cloudy swelling of the parenchyma of the liver, and a rather heavy deposit of fat was seen in the cells of the periphery of the lobules. There was no cirrhosis or evidence of infection. The spleen showed a pulp heavily infiltrated with lymphocytes and red cells. There was some fibrin on the capsule. The pancreas showed normal cords, ducts and islands. There were no pathologic changes in the kidneys, but the adrenal glands showed a general cellular degeneration with massive hemorrhage throughout both cortical and medullary zones. The capsule showed a little fibrosis, and outside the capsule in the periadrenal fat were thick nests of lymphocytes and deposits of fibrin and red cells. The ovaries and uterus showed no variation from the normal, but corpora lutea were found. Sections of the bowel were normal.

The following diagnosis was made: rupture of the thoracic duct with chylothorax; chyloperitoneum; emaciation; inanition; fatty infiltration of the liver; fibrinopurulent pleuritis, and terminal, fatal bilateral adrenal apoplexy.

COMMENT AND CONCLUSIONS

Rupture of the thoracic duct may occur because of hyperextension of the spine during an accident, the mechanism producing the rupture probably being aided by a fixation of a part of the duct between the tense and the sharp medial crus of the diaphragm anteriorly and the vertebral body posteriorly (fig. 4).

After rupture of the duct there is a localized extravasation of chyle, which persists for some days or weeks before the tissues of the mediastinum and pleura become sufficiently macerated and the fluid finally penetrates into the pleural cavity.

Early in the process the cystic extravasation of chyle may be detected in a roentgenogram (fig. 2*A*).

Early discovery and drainage of this cystic mass may obviate the later complications of chylothorax and chylous ascites and allow the rupture of the duct to heal spontaneously.

Autopsy in the case reported in this paper showed that chyle may be extravasated either because of a direct rupture of a chyle duct (causing in this case escape of chyle into the thoracic cavities) or by back pressure. (Here the duct was obstructed below the level of the diaphragm, and the abdomen was filled with chyle.) This patient hence exhibited both possible means of extravasation of chyle.

An operative procedure and approach for drainage of the usual site of traumatic rupture of the thoracic duct are presented and illustrated.

An unusual case of combined bilateral chylothorax and chylous ascites is reported.

INTRA-ABDOMINAL ADHESIONS

AN EXPERIMENTAL AND CLINICAL STUDY

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The formation of adhesions in the abdomen is a necessary reaction between apposing serous membranes, localizing bacterial invasion and limiting the effect of trauma. Where serous membrane is lacking, a far higher mortality prevails if the abdomen is invaded by infection or is subjected to trauma; therefore, surgical approach in the abdomen should and often is initiated by artificial stimulation of localizing adhesions, as in operations on the pharynx and the esophagus. Persistence of adhesions after the protective phase is passed, especially in structures that depend on the anatomic lumen, may become disastrous, as in the cerebrospinal system and in the gastro-intestinal or the genito-urinary structures. Harassing adhesions follow especially infections of the intra-abdominal viscera or trauma. Ever since intra-abdominal operative procedures became the method of choice in dealing with infections and trauma of the peritoneal cavity, the surgeon has observed that a seemingly successful treatment often results in persistent adhesions, which, in themselves, form a barrier to full recovery and necessitate frequent operations for the release of obstructive bands. Reports in the surgical literature are replete with accounts of cases in which operation has been performed for persistent obstructive adhesions. In one of these reported cases, I operated four times for adhesions, and the same patient was operated on four times by other surgeons. There are many patients in whom frank obstructions do not develop but who have partial obstructive lesions and consequently lead a semi-invalid life, often being branded as malingerers or psychopathic subjects. Dr. Charles Mayo once remarked: "Adhesions between movable viscera are of little consequence, but adhesions between abdominal viscera and a fixed point are sources of danger." As stated, peritoneal adhesions are the result of a natural phenomenon, but their persistence results frequently in complete or in incomplete obstruction of the bowel with the resultant chain of pathologic sequelae that are all too familiar.

Read before the sixth congress of the Pan American Medical Association, July 1935; also before the following medical societies in part or as a whole: Livingston County Medical Society, Michigan; Peoria Medical Society, Illinois; Schenectady Medical Society, New York; Marion Medical Society, Ohio.

Conducive to the formation of persistent adhesions are the following: (1) visceral perforations, with a resultant outpouring of intraperitoneal fluid, which becomes infected and literally bathes the contents of the abdomen with pus, causing violent reactions in the serous membrane; (2) drains stimulating the formation of thick local adhesions about them, followed by puckering and fibrosis and inflammatory processes, such as appendicitis, cholecystitis or infiltrating growths, and (3) rough handling of the peritoneal contents or massive removal of the contents, with resultant cooling of great areas of the intestinal tract. Powerful spread with retractors causes injury to wide areas of the peritoneum as well as has a paralyzing effect on the intestinal canal, with ballooning out of the intestines so that close contact minus peristalsis allows agglutination.[1] I am especially partial to spinal anesthesia in operations on the abdomen because intra-abdominal manipulation is facilitated by the great abdominal relaxation, as well as the contraction of the abdominal viscera.[2] Antiseptic solutions used in the preoperative preparation of the skin, which become dissolved in moist gauze and seep into the abdominal cavity, no doubt contribute to the formation of adhesions. The disastrous results in some patients who were successfully carried through catastrophic perforations of gangrenous appendicitis and later had symptoms of partial or complete obstruction are well known. Hertzler[3] demonstrated that fibrinous response in intestinal suture is complete within two hours, and Senn[4] demonstrated firm adhesion between peritoneal surfaces within from six to twelve hours.

In a recently published study of tissue reactions to drains, Spellman[5] noted the varied reactions of tissue to different types of drains, rubber drains delaying local repair and the formation of adhesions. Coffey[6] made use of the so-called Coffey quarantine drain in surrounding wicks of gauze with gutta-percha at the seat of infection, and in many cases he was able to check on the absence of adhesions on reoperation in following years. Of course, in by far the greatest percentage of cases

1. Benjamin, A. E.: Postoperative Peritoneal Adhesions, Minnesota Med. **17**:4 (Jan.) 1934.

2. Bogart, Leon M.: Spinal Anesthesia, Am. J. Surg. **18**:79 (July) 1932.

3. Hertzler, A. E.: The Peritoneum, St. Louis, C. V. Mosby Company, 1919, vol. 1.

4. Senn, quoted by Ochsner and Garside.[10]

5. Spellman, A. E.: Selection of Drainage Material, Arch. Surg. **28**:837 (May) 1934.

6. Coffey, R. C.: Abdominal Adhesions, J. A. M. A. **59**:1952 (Nov. 29) 1913.

the protective adhesions become digested or stretched out and are of no significance, but in from 2 to 5 per cent definite symptoms persist, owing to the fact that the adhesions change from a fibrinous to a fibrous character, and in many cases intestinal obstruction results. There are also a definite number of persons who are operated on who seem to have a predisposition to the formation of a thick scar, thick fibrous bands, or a keloid scar. In one of the cases reported, a woman had had a thyroidectomy performed elsewhere, with the formation of an unsightly, thick, painful keloid scar, which I resected and immediately treated with the roentgen rays. After a laparotomy, the same kind of a scar developed, and the patient suffered from symptoms caused by adhesions, until she was reoperated on and treated as outlined. In the case of an acute intestinal obstruction no hesitancy is experienced by the surgeon in advising a life-saving operation, but in the case of chronic involvement in which the division of adhesions is followed by reformation, surgical intervention is not indicated unless means of prevention of the reformation are possible. The cut adhesions become covered with fibrin, resulting in fibrous tissue, and the cycle begins anew. To reiterate, in many of the cases adhesions are due to injudicious handling, to contamination of the viscera with antiseptic solutions used to paint the skin or to the barbaric use of retractors, the stretching and traumatizing of the tissues being limited to the degree to which the intern pulls on the retractors or to the ability of the instrument to expand.

The endothelial cells forming the peritoneal surface are easily injured by trauma or infection as well as by prolonged exposure to the air, with resultant dehydration and cooling and subsequent healing if followed by the formation of thick fibrous bands. Blood left in the peritoneal cavity is considered by some to be conducive to deposits of fibrin, with the resultant formation of adhesions, though I have consistently left blood in the peritoneal cavity in cases of ectopic gestation and three times in instances of traumatic rupture of the spleen, with apparently no ill after-effect and an excellent immediate effect (clots were always removed). Careful peritonization of raw surfaces is a most essential preventive measure and should be done meticulously if possible. If sufficient peritoneum is not available, omentum attached or grafts should be used to cover raw surfaces.[7]

Various substances were used by the older surgeons to prevent adhesions: olive oil, liquid petrolatum, the so-called Cargile membrane (sterilized ox peritoneum), camphor liniment U. S. P., acacia U. S. P.,

7. Freeman, L.: Use of Free Omental Grafts, Ann. Surg. **63**:83, 1916.

etc. Norris and Davison [8] reported two cases in which liquid petrolatum was used and in which peculiar nodules developed which were similar in appearance and histologic structure; the adhesions reformed in greater degree. Several years ago I used ascitic fluid obtained from a patient with cardiovascular disease in two cases of severe adhesions, with good clinical results.

Substances tried heretofore were used with the idea of forming a protective coat until a certain amount of healing occurred in the raw surfaces. Most of these substances failed, owing to the severe reactions evolved.

The character of the fluid after bacterial invasion differs so that a streptococcic infection is less productive of adhesions than infections with colon bacillus. Not all infections or injuries evoke a similar response, because in cases of peritonitis caused by a streptococcic infection the exudate is poor in fibrin and leukocytes, and the adhesions formed are not formidable, while infection with colon bacilli causes an exudate rich in fibrin and leukocytes, resulting in localization and the formation of fibrous bands. The surface of the peritoneum is almost the same as that of the skin and is capable of secreting a lubricant fluid in which the abdominal organs move. It also has great absorptive power. In a localized infection or irritation there is an outpouring of the peritoneal fluid, absorption also taking place; that which remains forms a protective zone, sealing the omentum and loops of the bowel around the area, forming a barrier, or, as Coffey expressed it, nature's quarantine. The remains of nature's quarantine process, unless absorbed or stretched out, remain as abdominal junk, a descriptive term applied to them by Joseph Price. It is claimed by some authorities that persons with exceptional reparative powers are more prone to the formation of adhesions, the local reaction to injury, mechanical or bacterial, producing a greater response. Adhesions are produced in the dog less readily and rapidly than in the hog, but the latter is far more susceptible to sepsis. In acute and virulent processes, the spread of the inflammation becomes limited only by distant formation of adhesions away from the violent attack, as noted by Curtis [9] in the thick dense adhesions formed between the liver and the parietal peritoneum, the result of a gonococcic infection of the pelvic organs. Extension from within the lumen may penetrate through the serosa, the lumen of one loop prac-

8. Norris, J. C., and Davison, T. C.: Peritoneal Reaction to Liquid Petrolate, J. A. M. A. **103**:1846 (Dec. 15) 1934.

9. Curtis, A. H.: Adhesions of Anterior Surface of Liver, J. A. M. A. **99**:2010 (Dec. 10) 1932.

tically forming one inflammatory mass with the lumen of another loop, the infection resulting in a very thick fibrous adhesive band.

The functions of the organs contained in the peritoneal cavity are the preparation and the absorption of food and the elimination of the wastes resulting from the foregoing functions. Disturbance of any one of these functions usually results in disturbance to the others. Freedom on motion of the alimentary tract is most essential, especially of the large bowel, because the posterior half of the lumen of the large bowel is semiattached, acting as a trough. Therefore, adhesions causing attachment to the upper surface of the serous covering render the large bowel almost pipelike, and propulsion is lost by that portion, with dilatation above and below the formed attachment. Ochsner and Garside [10] found that theoretically the use of a digestive ferment is fully justified because of its ability to destroy fibrin. Yardumian and Cooper [11] reported the experimental use of pepsin extracted with water and glycerin as successful in 62 per cent of a total of one hundred and eighteen operations on forty-four rabbits.

Wangensteen [12] cited five cases of postoperative adhesions in which 1,000 cc. of air was injected into the abdomen and the patient's buttocks were elevated on two pillows, causing the air to be interspersed between the umbilicus and the bowel; good results were obtained in one case. I believe that this method is faulty because the worst adhesions do not necessarily appear between the bowel and the parietal peritoneum. In my own cases I have often seen adhesions between the small and the large bowel practically covering the anterior portion of the ascending and the descending colon. In several of my cases there have also been severe adhesions between the duodenum and the bed of the liver after cholecystectomy. In one case in particular the adhesions in the upper right quadrant were so thick that it was impossible to divide them without causing injury to the bowel. The patient was treated with a solution of papain over a year and a half ago and has apparently been well since. This observation is opposite to the view held by Fausel,[13] who, experimenting with papain, found that it acts

10. Ochsner, A., and Garside, E.: Peritoneal Adhesions, Surg., Gynec. & Obst. **54**:328 (Feb.) 1932.

11. Yardumian, K., and Cooper, D. H.: Pepsin in Prevention of Abdominal Adhesions, Arch. Surg. **29**:264 (Aug.) 1934.

12. Wangensteen, O. H., in discussion on Benjamin.[1]

13. Fausel, E. G.: Experimental Postoperative Adhesions, M. Times & Long Island M. J. **62**:1 (Jan.) 1934.

decidedly in the prevention of experimental adhesions but has no action on formed adhesions which have not been divided.

Rea and Wangensteen [14] also reported the successful use of a 1 per cent solution of sodium ricinoleate (castor oil soap), papain 1:50,000, a merthiolated solution of amniotic fluid of cow's and defibrinated rabbit's blood. All of these were found to prevent the formation of experimental adhesions. The authors are especially partial to sodium ricinoleate, because they found it just as valuable in the presence of infection as when no infection is present. All the other substances mentioned are not effective in the presence of infection. The clinical applications of sodium ricinoleate have been too few, and Rea and Wangensteen drew no conclusions; the amount used was 60 cc., which was poured into the abdominal cavity before closure.

Ochsner and Garside,[10] Kubota [15] and Walton,[16] after experimentation with enzymes, concluded that papain (a vegetable enzyme) is by far the most suitable for clinical use, being superior to trypsin (animal enzyme) in that its effectiveness is of longer duration. Parke, Davis & Co., in cooperation with Walton and Ochsner, produced a sterile standard preparation which I have been able to use in my experimental and clinical application. The ampules contain 0.25 mg. of papain. The effect of papain, according to Walton,[17] is supposed to be due to a direct proteolytic action, and the concentrations used varied from 1:25,000 to 1:50,000. Concentrations stronger than these will cause, in many instances, irritation and peritoneal bleeding. Papain is derived from the unripe fruit of the papaw tree; it is active in neutral and alkaline mediums.

The early workers with papain encountered a great deal of difficulty in obtaining a solution of the powder supplied in the ampule. After trying many solutions I finally concluded that sodium citrate in a 0.25 per cent solution in distilled cool water forms the best base. This can be obtained by shaking the powdered papain into a wide vessel containing 500 cc. of 0.25 per cent citrated distilled water and agitating slowly and then adding the solution to 1,000 cc. of distilled water,

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14. Rea, A. E., and Wangensteen, O. H.: Comparative Efficacy of Substances Employed in Prevention of Intra-Peritoneal Adhesions, Proc. Soc. Exper. Biol. & Med. **31**:1060 (June) 1934.

15. Kubota, quoted by Walton.[16]

16. Walton, R. P.: The Behavior of Papain in the Peritoneum, J. Pharmacol. & Exper. Therap. **43**:487 (Nov.) 1931.

17. Walton, R. P.: Papain Preparations Suitable for Prevention of Adhesions, Proc. Soc. Exper. Biol. & Med. **28**:922 (June) 1931.

making 1,500 cc. in all of 1:25,000 solution, which is the strength advocated.

Walton [16] found that the concentration of 1:500 produced a fall in blood pressure, a fall in temperature of from 1 to 1.5 C. and hemorrhagic infiltration as well as edema and partial digestion of the wall of the intestine.

INDICATIONS FOR OPERATIVE PREVENTION OF ADHESIONS

Previous intra-abdominal operations followed by symptoms clearly pointing to obstructive adhesions and interference with the normal physiology of the alimentary tract are indications for the operative prevention of adhesions. The pain may be more or less constant at the site of the previous operation, or it may be distant from it. Acute

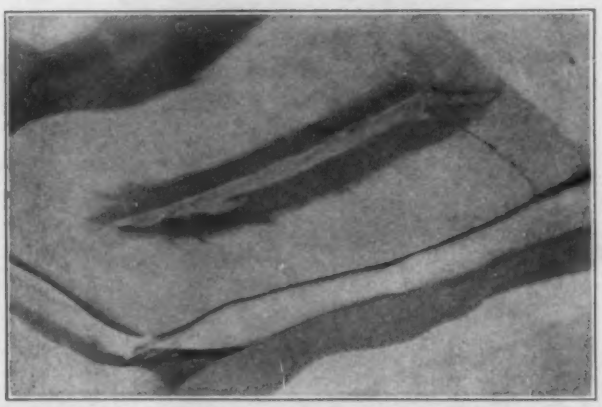

Fig. 1. (patient 10).—Photograph showing a xeloid scar before operation on Sept. 26, 1934.

exacerbation of the pain characterized by cramplike seizures, followed by periods of comparative freedom from pain, are quite characteristic of obstructive lesions of the alimentary tract. Vomiting may be a late symptom and should not be used as a criterion. One or two stools may be effected with enemas, and yet obstruction may be present. Frequent seizures of the aforementioned type are practically pathognomonic of obstruction of the bowel. It is not wise to wait for complete obstruction of the bowel before an operation is decided on, nor should one wait for the symptoms of deep shock to appear before operating. In cases in which gangrene of the bowel is present, the solution of papain and sodium citrate is not indicated and should not be used, as the fluid becomes infected and helps spread peritonitis.

Fig. 2 (patient 10).—Photograph showing the open abdomen on the same date. Note the adhesions.

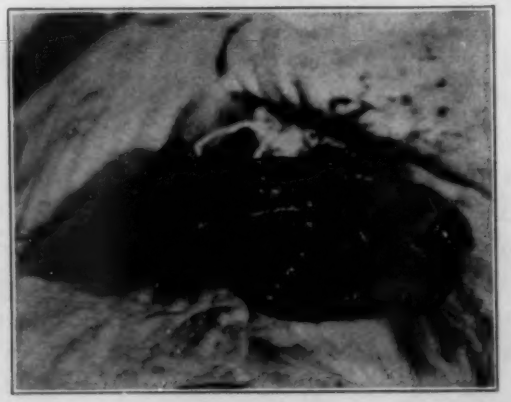

Fig. 3 (patient 10).—Photograph taken at operation six months later for postoperative hernia. Note the absence of adhesions.

TECHNIC OF PROCEDURE

If possible, the patient should be prepared two or three days prior to operation with a bland nonresidue diet. Saline cathartics are indicated, and two enemas should be given daily. A thorough deflation of the bowel is very helpful. To complete deflation of the alimentary tract, gastric decompression by instituting constant gastric drainage may have to be done. Two doses of pitressin the day before the operation and one dose on the operating table help to keep the bowels contracted and make the operative procedure much easier

The usual preparation is done, care being taken to remove any excess of the antiseptic used and to dry the skin well. Entrance into the abdomen is best gained by the resection of one of the old scars

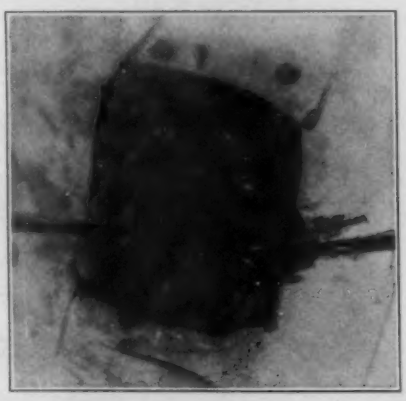

Fig. 4 (rabbit 1).—The normal appearance of the abdominal contents of a rabbit.

through its full thickness, so that the scar tissue of the peritoneum is also removed. Sharp dissection of all adhesions and removal of all tags should be practiced; oozing should be stopped with the administration of epinephrine or slight pressure; all clots must be removed. One should refrain from using any retractors intraperitoneally or from manipulating the bowel any more than is needed. The omentum must be dissected free from adhesions so that it is mobile. One should be especially careful to effect thorough dissection of the adhesions around the large intestine during the operation. The bowel must not be brought outside of the abdomen, and any handling of the bowel should be done with wet gauze without excessive pulling or tugging. Good relaxation is imperative, and for this reason in most of my cases operation was done with the patient under spinal anesthesia, as it affords

Fig. 5 (rabbit 2).—Massive formation of adhesions three weeks after irritation plus the introduction of pus followed by the introduction of a solution of papain and sodium citrate used and separation of the adhesions.

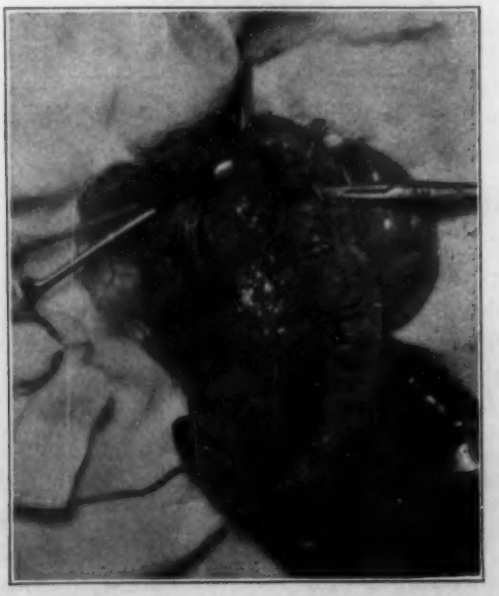

Fig. 6 (rabbit 3).—Photograph of the operative field showing the adhesions about the forceps, caused by the introduction of an infected sponge.

an excellent field without undue strain. When all dissection has been completed and hemostasis has been attended to, the peritoneum is picked up with a row of forceps and stretched upward, and the edges are brought up close to each other. The preparation of the fluid in the meantime has been accomplished by an assistant. Two methods may be followed in introducing the prepared solution into the abdominal cavity. The first method consists of connecting a catheter with the container of the solution and allowing it slowly to fill the abdominal cavity. The other method being used by me now consists of pouring from

Fig. 7 (rabbit 4).—Photograph of the operative field eight weeks after the introduction of a solution of sodium citrate and papain and separation of adhesions showing the absence of adhesions which had been caused by the introduction of an infected sponge.

200 to 300 cc. of the fluid into the abdomen every few minutes until 1,500 cc. has been used. The important step is to cover all the abdominal organs with the fluid and to be able to draw the omentum over the abdominal contents. The closure of the peritoneum is effected by everting the edges so that no raw surface of the peritoneum points into the abdominal cavity. Each suture is back stitched and rolled so that when one is through there is a rolled water-proof suture line. The suture is tied in several places, and the peritoneal edges are held

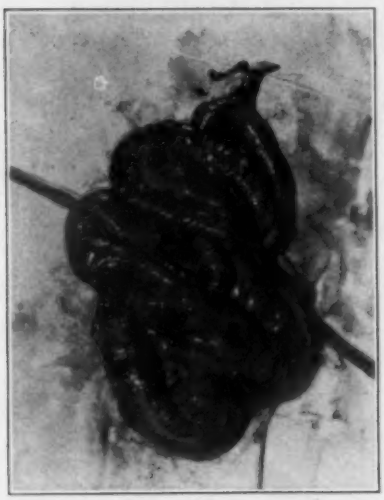

Fig. 8 (rabbit 5).—Photograph of the operative field after treatment with a solution of sodium citrate and papain, and separation of the adhesions. Note the absence of massive adhesion formation.

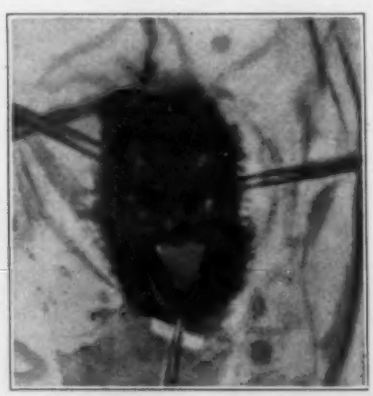

Fig. 9 (rabbit 6).—Photograph of the operative field after treatment with a solution of sodium citrate and papain and separation of the adhesions showing the complete absence of adhesions which had been caused by the introduction of an infected sponge.

up so that no spilling is done; the other layers are sutured in the usual manner. Distention of the bowel postoperatively is guarded against by the administration of ten doses of pitressin and by constant gastric deflation for three days. Fluids should be supplied intravenously from 4,000 to 5,000 cc. in twenty-four hours by the drop method. No drastic cathartics should be given. On the fourth day 1 ounce of liquid petrolatum given morning and evening with a small enema the following morning usually produces evacuation of the bowel. I have noted that when considerable spilling of the fluid occurred outside of the abdominal cavity onto the wound, faulty healing resulted with a ventral hernia. There was no infection in any of my cases.[18]

EXPERIMENTAL STUDY

An experimental study was made on thirty-eight rabbits and thirty patients to determine the value of papain in the prevention of the reformation of intra-abdominal adhesions. The results in the rabbits are presented in table 1. A summary of the data on the thirty patients is presented in the following outline, and an analysis of the results obtained is given in table 2.

Status of patients treated with the solution:

No. with no or one previous operation	8
No. with two previous operations	9
No. with three previous operations	6
No. with four previous operations	4
No. with five or more previous operations	3
Total	30

Time elapsed since treatment:

Less than one year	8
Between one and two years	12
Between two or more years	8
Deaths	2
Total	30

18. Since reporting these cases, nine more may be added to this group with uniformly good results. The technic was somewhat changed in the cases of severe involvement, 25 mg. of papain being dissolved in 500 cc. of sodium citrate solution (one 50 cc. ampule of 2.5 per cent sodium citrate was dissolved in 500 cc. of distilled water).

Sex:

Male..... 4
Female.....26

Race:

Negro*..... 3
Others.....27

* About 10 per cent, the same proportion as in population.

Results obtained:

Deaths..... 2
Poor results and fair..... 2
(One patient reoperated on and solution used again)
Good clinical results verified by secondary operation and one by photograph and operation..... 2
(One patient reoperated on for hernia, photograph taken, and solution used again)
(One patient reoperated on for hernia by another surgeon and reported by him to me)
Good clinical results.....22

A summary of the experiments on the animals follows: The mortality was 100 per cent when alcohol and ether were used to lavage the abdomen. When resection of the bowel was done a solution of papain had no influence on the ultimate course. The introduction of papain into the abdomen in the presence of gauze did not prevent formation of the adhesions, nor did it retard infection, the results being similar to those in the controls in which physiologic solution of sodium chloride alone was used. When papain in a solution of sodium citrate was used, the formation of adhesions was the least, and when adhesions formed they were very slight. From other experiments not reported here, I believe that a solution of sodium citrate alone has a mild action in preventing experimental formation of adhesions.

All told, there were thirty-eight rabbits on which forty-four operations were performed, with twenty deaths. Most of the rabbits had been previously used for routine laboratory experiments. The death rate was especially high in the controls. Papain in a solution of sodium citrate had a decided influence in the prevention of adhesions and mortality, being seemingly more effectual than any other substance used in these experiments.

TABLE 1.—*Results of Experiments on Rabbits*

Operation	Solution Used	No. of Animals	Recovery	Died	Postmortem or Operative Picture
Irritation; scraping plus sponges	Physiologic solution of sodium chloride	3	0	3 (4th to 6th day)	Operative picture: frank pus around sponges, many adhesions, distention of bowel and spreading peritonitis
Irritation; scraping; application of tincture of iodine	Sodium citrate; papain	6	6	0	Operative picture: reoperated on at intervals of from 10 to 60 days; no adhesions in four animals; thin scattered adhesions in two; whitish plaques covered the viscera and parietal peritoneum, becoming dimpled in the longer interval
Irritation; scraping; application of tincture of iodine	Physiologic solution of sodium chloride	3	2	(4th day)	Postmortem picture: distention of abdomen; bowel adherent to wound Operative picture: two animals that lived reoperated on; moderate adhesions
Reoperated on; adhesions divided	Papain; sodium citrate	2	2	0	Operative picture: reoperated on three weeks later; abdomen free from adhesions
Irritation; scraping; application of tincture of iodine	Distilled water; papain	3	3	0	Operative picture: reoperated on on 12th day; all had fairly firm adhesions
Division of adhesions	Sodium citrate; papain	3	2	1 (1st day)	Postmortem picture: abdomen filled with bloody serum Operative picture: two animals that lived reoperated on on 20th day; moderate adhesions of bowel to wound
Irritation; scraping; application of tincture of iodine	Sodium citrate	5	4	1 (3d day)	Postmortem picture: firm adhesions of bowel to wound; distention Operative picture: four animals that lived reoperated on in three weeks; no adhesions in one; firm, generalized adhesions in three
Irritation; scraping; application of tincture of iodine; resection of bowel	Sodium citrate; papain, 1:25,000	3	0	3 (3d day)	Nothing found at autopsy
Irritation; resection of bowel	None	3	0	3 (1st day)	Nothing found at autopsy
Irritation; scraping; application of tincture of iodine	70% alcohol lavage	3	0	3 (next day)	Postmortem picture: peritoneum appeared red and flaxy; serosanguineous fluid found
Irritation; scraping; application of tincture of iodine	Lavaged with ether	3	0	3 (on table)	No cause of death found
Irritation and scraping plus gauze sponge	None	3	1	2 (4th day)	Postmortem picture: distention of bowel; generalized peritonitis; many firm adhesions Operative picture: animal that recovered had adhesions; bowel firmly adherent to sponge
Reoperated on; sponge removed; four weeks later reoperated on	Sodium citrate papain	1	1	0	Operative picture: no adhesions found; peritoneum studded with whitish flakes
Irritation; scraping plus sponge left in	Sodium citrate; papain	3	3	0	Operative picture: reoperated on 4th day; moderate adhesions; serous fluid somewhat bloody; smear showed infection with colon bacilli; culture showed gas-producing organism

TABLE 2.—*Experimental Study of Thirty Patients on Basis of Results*

Patient, Date and Age	Previous Operations; Condition of Scars	Symptoms and Signs	Operative Findings	Results
		DEATH		
M.I. 9/19/32 17 yr.	One pelvic operation; gangrenous Meckel's diverticulitis; enterostomy; scars taut and red	Pain in lower portion of abdomen; vomiting; frequent colics, necessitating loss of work; painful scars; weight 81 pounds (36.7 Kg.); condition very poor	Few strong adhesions in lower portion of abdomen; cecum especially bound down; adhesions divided; 250 cc. of papain in physiologic solution of sodium chloride administered; patient did poorly and was uncooperative; pulled stomach tube out; gastrotomy performed for acute gastric dilatation on 9/26/35, under tri-bromethanol anesthesia *	Died 9/30/32, two weeks after operative procedure; autopsy showed acute gastric dilatation, raw areas over bowel in right quadrant and absence of adhesions
L. L. 2/6/35 49 yr.	Cholecystectomy and appendectomy, hysterectomy; division of adhesions ten days prior to last operation by another surgeon	Vomiting, moderate distention and pain in abdomen; poor results with enema and posterior pituitary after division of many adhesions, which were thick and numerous, according to description of operating surgeon; patient's condition poor	Very thick adhesions reformed in 14 days, binding small bowels in one mass and adherent as a whole to last incision; separation of adhesions made through old incision; reformed adhesions were hard and very thick, requiring dissection with knife; 1,500 cc. of papain in sodium citrate solution administered	Died two days after operation; autopsy showed many old adhesions, perforation of bowel and inflammation of the ileum and marked fibrosis of the liver
		POOR AND FAIR RESULTS		
A. S. 4/11/34 56 yr.	Suspension; hysterectomy; removal of adnexa; division of adhesions; thick scars and suprapubic hernia	Constant pain in scars and abdomen; periodic distention and colicky pains; weight 85 pounds (38.6 Kg.)	Massive adhesions; sigmoid adherent to cecum; constriction of right ureter; right kidney enlarged; separation of adhesions and freeing ureter; 500 cc. of papain in physiologic solution of sodium chloride administered; tri-bromethanol anesthesia used	Poor; patient kept on complaining and having symptoms Fair; somewhat better; still not well
Reoperated on 9/25/34	Same as in A. S.; recurrent hernia	Same as in A. S.	Adhesions much less; fistulous opening from cervix into abdomen; removal of cervix; 1,500 cc. of papain in distilled water administered; repair of hernia; adhesions divided; tri-bromethanol anesthesia used	
M. L. 6/12/34 36 yr.	Hysterectomy, cholecystectomy and appendectomy; two thyroid operations; scars thick and keloid	Constant pain in left lower abdominal quadrant; constant pain in region of gallbladder; periodic obstipation; loss of weight	Massive adhesions in region of gallbladder and left lower abdominal quadrant; left ovary cystic, enmeshed in adhesions; ovary removed and adhesions separated; 1,500 cc. of papain in sodium citrate administered; tri-bromethanol and general anesthesia used	Improved; gained weight; still complains of soreness in lower part of abdomen, but none in the region of the gallbladder. Comment: It is noteworthy that in the area where a small mole was removed from the right thigh, the scar healed with a thick indurated base
A. B. 5/29/34 44 yr.	Suspension; cholecystectomy; appendectomy; pelvic operation; exploration; scars moderately thick and recrossed	General abdominal pain, vomiting, constipation, diarrhea and colic; lost 20 pounds (9.1 Kg.); suprapubic postoperative hernia	Massive localized adhesions; opening sharply segregated in locale of surgical intervention; old median scar resected; removal of adnexa and supravaginal hysterectomy; 1,500 cc. of papain in sodium citrate solution administered; tri-bromethanol anesthesia used	Improved; has some complaints; vague in character; no colic; improvement slow but steady

* Tri-bromethanol in amylene hydrate was the form of anesthetic used when tri-bromethanol anesthesia is mentioned.

anesthesia used

* Tri-bromethanol in amylene hydrate was the form of anesthetic used when tri-bromethanol anesthesia is mentioned.

TWO PATIENTS OPERATED ON; ONE PHOTOGRAPHED				
Mc. C. 3/24/34 32 yr.	Operations on pelvis, gallbladder and appendix; suprapubic keloid scars; postoperative hernia	Very obese; protruding hernia; signs of partial obstruction of bowel; vomiting with diarrhea; abdominal distention; dull aching pain in right lower quadrant; region of scars very painful	Large intraligamentous cyst on right side; many adhesions, thick and constricting; one loop of bowel tightly held in adhesions; resection of old suprapubic scar; resection of cyst; resection of sac and repair of hernia; 1,000 cc. of papain in sodium citrate solution administered; spinal anesthesia used	Reoperated on on 5/27/35, with following report: ventral hernia with several loops of bowel and omentum on the abdominal fascia; exploration of abdominal cavity showed no adhesions to intestines or adjacent viscera
W. E. 2/9/34 24 yr.	Suprapubic hysterectomy; appendectomy; resection of bowel; separation of adhesions; two scars in lower part of abdomen, one scar widened out, and hernia	Vomiting of three days' duration; no bowel movement; moderate distention; postoperative ventral hernia protruding	Ventral hernia; bowel adherent to sac; no gangrene; intestines matted firmly throughout abdomen; moderate distention; careful dissection of adhesions; resection of sac and freeing of herniated bowel; papain in sodium citrate solution; closure Reoperated on 11/26/34; ventral hernia; 1.500 cc. of papain in sodium citrate solution administered Comment: This patient had papain twice with excellent clinical results	Clinically good; patient reentered hospital 11/26/34 for repair of recurrent ventral hernia; photograph of abdominal contents taken showing abdomen free from adhesions
GOOD RESULTS				
W. R. 3/11/32 44 yr.	Ruptured appendix; enormous keloid scar; one operation for adhesions	Acute obstruction of bowel; symptoms of chronic partial obstruction several years	Thick cartilaginous bands encircling part of ileum and many waves of adhesions; dissection of adhesions and invagination of injured small bowel; 1,500 cc. papain in physiologic solution of sodium chloride administerd; spinal anesthesia used	Good; no complaints
G. E. 3/19/32 29 yr.	Appendectomy three years ago; redrained operative field for adhesions	Acute obstruction of bowel; very obese; pregnant five months; ventral hernia; bulging not strangulated	Thick bandlike adhesions; resection of scar and dissection of adhesions; 1,500 cc. of papain in physiologic solution of sodium chloride administered; spinal anesthesia used	Miscarriage; condition good; no complaints
M. C. 3/24/32 30 yr.	Four abdominal operations; scars thick and painful	Pain in abdomen; chronic obstruction with occasional exacerbation; very obese	Abdomen a complete mass of adhesions with many constricting bands; separation of adhesions; papain in physiologic solution of sodium chloride, 1:25,000, administered; spinal anesthesia used	Good; recovery slow
B. E. 5/31/32 35 yr.	Eight operations, including two or three intestinal resections; abdomen all scars	Acute intestinal obstruction; abdomen distended; vomiting; very ill	Massive adhesions; distal part of ileum adherent to midpubic incision; strangulated; left herniation of strangulated loop and separation of adhesions; 1,500 cc. of papain in physiologic solution of sodium chloride administered; spinal anesthesia used	Very good
P. K. 6/28/32 46 yr.	Two operations, gallbladder and pelvic; thick indurated scars	Pain; chronic obstruction; acute attacks	Thick ropelike adhesions in hepatic area and right lower quadrant; separation of adhesions; 1,500 cc. of papain in physiologic solution of sodium chloride administered; spinal anesthesia used	Good

TABLE 2.—*Experimental Study of Thirty Patients on Basis of Results—Continued*

Patient, Date and Age	Previous Operations; Condition of Scars	Symptoms and Signs	Operative Findings	Results
J. M. 7/28/32 34 yr.	Two operations; thick scars	Generalized abdominal pain; acute exacerbation of chronic abdominal pain; vomiting; moderate distention	Resection of midpubic scar; obstruction of terminal ileum field; adhesions separated; 1,500 cc. of papain in physiologic solution of sodium chloride administered; spinal anesthesia used	Good
W. M. 9/18/32 42 yr.	Two operations, one for obstruction of bowel	Abdominal pain in region of scars; distention and vomiting; small particles of feces; emaciated	Ropelike adhesions in lower part of abdomen; retrocecal appendix; cecum adherent to wound; appendectomy and separation of adhesions; 1,500 cc. of papain in physiologic solution of sodium chloride administered; spinal anesthesia used	Good
W. B. 10/9/33 34 yr.	Two operations, one for adhesions with obstruction of bowel; keloid scars	Acute obstruction of bowel; exacerbation of chronic abdominal condition	Ileum obstructed by bands of adhesions; abdomen full of waves of adhesions; resection of loop of ileum; 1,500 cc. of papain in physiologic solution of sodium chloride administered; spinal anesthesia used	Good
S. A. 1/15/34 39 yr.	One operation, vaginal hysterectomy; no scar	Chronic abdominal pain, acute attacks centering in pelvic region; bloating	Many adhesions in pelvic abdomen; sigmoid and cecum adherent to stump; right oophorectomy, appendectomy and separation of adhesions; 1,500 cc. of papain in sodium citrate solution administered; spinal anesthesia used	Good
G. R. 3/19/34 26 yr.	One operation; thick scar	Chronic abdominal condition for two years; loss of weight; bloating	Enmeshed uterus; adnexa removed previously; frozen pelvis; sigmoid adherent to scar; hysterectomy and separation of adhesions; 1,500 cc. of papain in sodium citrate solution administered; spinal anesthesia used	Good
F. M. 3/23/34 28 yr.	One operation; normal appearing scar	Constant pain in lower part of abdomen; two acute attacks diagnosed as obstruction of bowel relieved by medical treatment	Uterus frozen in mass of adhesions; both tubes enmeshed; right salpingo-oophorectomy, left salpingectomy, suspension and separation of adhesions; 1,500 cc. of papain in sodium citrate solution administered; tri-bromethanol anesthesia used	Patient developed mental symptoms; abdominal condition good; psychosis cleared up
T. S. 3/26/34 18 yr. male	One operation; thick scar	Constant pain in lower part of abdomen following appendectomy two months before; bowel movements possible but difficult; emaciated	Mass of adhesions in iliocecal region; distention of large bowel; division of adhesions and exploration; 1,500 cc. of papain in sodium citrate solution administered; tri-bromethanol anesthesia used	Good
S. G. 4/2/34 26 yr.	No operations	Generalized abdominal pain; obstipation; frequent colicky attacks, with diarrhea and abdominal distention	Abdomen filled with adhesions in region of gallbladder between liver and parietal peritoneum, lower part of abdomen and pelvis; separation of adhesions, appendectomy and plastic operation on both adnexa; 1,500 cc. of papain in sodium citrate solution administered; gas and ether anesthesia used	Good all over abdomen; moderate amount of tenderness in region of gallbladder

istered; gas and ether anesthesia used

B. J. 5/10/34 56 yr.	Two operations; postoperative ventral hernia scar widened; very obese	Increasing difficulty in defecation, with pain in lower part of abdomen during defecation; distention, occasional strangulation in hernia reducible	Massive adhesions involving distal and descending colon; adhesions from one side of abdomen across; herniated loops of bowel adherent; separation of adhesions and repair of hernia; 1,000 cc. of papain in sodium citrate solution administered; tri-bromethanol anesthesia used	Good; no complaints
R. L. 5/19/34 44 yr.	Five operations, two ventral hernias; postoperative scars thin and stretched out in other adhesions; radium treatments to cervix	Strangulation of bowel while straining at stools; constant abdominal pains; partial bowel obstruction several times; diarrhea and constipation	Two hernial protrusions, masses of adhesions around hernias and region of gallbladder; resection of scars at hernia, separation of adhesions and repair of hernia; papain in sodium citrate solution administered; tri-bromethanol anesthesia used	Good
S. L. 7/30/34 27 yr.	Appendectomy; scar widened	Pain in area of operation and scar; vomiting and distention; emaciation	Area of scar contains many adhesions; cecum adherent to scar; left ovary cystic; right salpingo-oophorectomy and separation of adhesions; papain in sodium citrate solution administered; tri-bromethanol anesthesia used	Good
C. E. 8/14/34 36 yr.	Three operations; hernia, two scars only being present	Pain in lower part of abdomen; chronic and boring; distention; obstipation; emaciated	Postoperative ventral hernia, many intra-abdominal adhesions involving small and large bowel; separation of adhesions and removal of left ovarian cyst; papain in sodium citrate solution administered; tri-bromethanol anesthesia used	Good
M. A. 9/25/34 22 yr.	Three operations, one ileostomy for obstruction; postoperative ventral hernia; scars thick	Pain in region of scars; intestinal obstruction three times; operated on once; distention periodic	Many adhesions; hernia enmeshed in adhesions; resection of median scar, separation of adhesions and repair of hernia; papain in sodium citrate solution administered; spinal anesthesia used	Good
M. C. 9/23/34 33 yr	One operation; ruptured gastric ulcer; enterostomy; scar thin	Acute obstruction of bowel	Adhesions at site of enterostomy; loop of ileum adherent to wall; many adhesions in pyloric region; release of obstruction and separation of adhesions; 1,500 cc. of papain in sodium citrate solution administered; spinal anesthesia used	Good
F. V. 1/7/35 21 yr.	Operations, for appendicitis; pelvic condition and obstruction of bowel; wide thick scar	Constant pain in lower part of abdomen; acute attacks, relieved by medical means; obstipation and diarrhea; considerable loss of weight	Massive adhesions in appendiceal region and pelvis, also in region of left colon; separation of adhesions; 1,500 cc. of papain in sodium citrate solution administered; tri-bromethanol anesthesia used Comment: Patient complained of pain on defecation for three or four weeks; feels good now	Good
S. C. 5/1/35 20 yr.	Two operations, appendectomy and exploratory for intestinal hemorrhoids	Severe pain in whole abdomen; cramps and vomiting; massive hemorrhages from bowel	Massive adhesions involving whole of abdomen; loops of bowel adherent to scar and omentum; separation of adhesions; 1,500 cc. of papain in sodium citrate solution administered; tri-bromethanol anesthesia	Undetermined; immediated result good

SUMMARY AND CONCLUSION

A study of intra-abdominal adhesions based on the experimental findings in thirty-eight rabbits and thirty human patients is presented. This study was made with papain, standardized and prepared according to the method of Ochsner and Walton, by Parke, Davis & Co. The earlier works of Walton, Kubota and others were freely consulted.

In the experimental and clinical cases presented, I found that a solution of 0.08 per cent sodium citrate in distilled water in which 25 mg. of papain is dissolved makes a satisfactory solution. I believe that sodium citrate has a synergistic action with papain.

All the earlier work on the prevention of the reformation of intra-abdominal adhesions was built on the theory that a mechanical lubricant would stop the natural process of production of fibrin and fibrous tissue or stop the phenomenon of natural defense.[14] The method herein described is based on the response of the defense mechanism, the solution acting directly on the fibrin, preventing the formation of the end-product in diverting the process of peritoneal reaction to a digestion of the fibrin formed. Thirty clinical cases are cited in which a solution of papain was used. In two cases death occurred which could not be attributed to the drug used; in two the results were poor and in twenty-six they ranged from good to excellent.

DIFFERENTIAL ANALYSIS OF BILE ACIDS IN HUMAN BILE FROM FISTULAS

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In a previous communication [1] the differential bile acid analysis of a large series of samples of bile removed from gallbladders at operation was reported. The bile was analyzed for bile acids conjugated with taurine and with amino-acetic acid, for cholic acid, for desoxycholic acid and for free bile acids. It was shown that the point of greatest significance was the variation in the proportions of the different bile acids in any one sample. Thus, in samples of bile removed from normal gallbladders, cholic acid formed about one half of the total bile acid content, while about 20 per cent of the total was in the form of free bile acids. In cases of chronic cholecystitis, the cholic acid content averaged about 30 per cent and the free bile acid content about one third of the total bile acid content. In sharp contrast, analysis of the bile from the gallbladder in cases of acute cholecystitis revealed that the cholic acid content averaged about one sixth and the free bile acid content about 50 per cent of the total bile acid content. The total bile acid content in cases of acute cholecystitis averaged about one fourth of that in cases of chronic cholecystitis. The fall in the ratio of cholic acid and the rise in the relative percentage of free bile acids were apparently due to the fact that the various bile acids were absorbed in a differential manner by the inflamed wall of the gallbladder.

In several cases, however, in which the gallbladder was found to be practically normal, marked variations in the bile acids were noted. These variations were thought to be due to pathologic changes in the liver. That the liver can secrete the various bile acids in abnormal proportions has already been noted by Andrews and his co-workers.[2] It seemed, therefore, to be of some importance to utilize the method of differential bile acid analysis in investigating the direct secretion of

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From the Surgical Service of Dr. Ralph Colp and the Laboratories of the Mount Sinai Hospital.

1. Colp, R., and Doubilet, H.: Differential Analysis of Bile Acids in Human Gallbladder Bile, Arch. Surg. **33**:913 (Dec.) 1936.

2. Andrews, E.; Hrdina, L., and Dostal, L. E.: Etiology of Gallstones: II. Analysis of Duct Bile from Diseased Livers, Arch. Surg. **25**:1081 (Dec.) 1932.

the liver in cases of drainage from a fistula in human beings. The strong influence of the gallbladder could thus be excluded, except in a fistula of the type seen after cholecystostomy. It is evident that such an investigation might be of great value in studying the etiologic factors and the underlying mechanisms involved in the different pathologic conditions of the liver and biliary tract.

METHOD

The method for the differential bile acid analysis has been previously described. All determinations were carried out in duplicate. In general, 5 cc. of bile from the fistula was extracted with 80 cc. of boiling 95 per cent alcohol, and the method of Schmidt and Dart used to determine the bile acids conjugated with taurine and with amino-acetic acid. Depending on the apparent concentration of the bile, from 15 to 40 cc. of bile was precipitated with zinc hydroxide, and the clear bile salt extract was used to determine both the cholic acid by a modification of the procedure of Gregory and Pascoe (colorimetric) and the total bile acids by an iron precipitation method. The percentage of free bile acid was estimated by subtracting the conjugated bile acids from the total bile acids. The bile acids, expressed as desoxycholic acid, also included, of course, the small amounts of anthropodeoxycholic and lithocholic acids present in human bile in small amounts. The figures for the total bile acid content do not include the weight of the conjugated taurine and amino-acetic acid, since the percentages are calculated on the basis of the hydrolyzed bile acids.

MATERIAL

Bile drained from a fistula in twenty-seven human patients was analyzed either on consecutive days after operation or on every second or third day. As a rule, since in most cases bile entered the intestinal tract to some extent, quantitative studies could not be carried out.

The cases may be conveniently summarized under three divisions.

I. Release of complete or incomplete obstruction (17 cases)
   A. Complete obstruction (2 cases)
      1. Chronic pancreatitis (case 1)
      2. Carcinoma of the head of the pancreas (case 2)
   B. Incomplete obstruction (15 cases)
      1. Without stone (cases 3 and 4)
      2. Calculi of the choledochus (cases 5 to 11)
      3. Stricture (case 12)
      4. Pancreatitis (cases 13 to 17)

II. Cholangeitis and cholangeolitis (7 cases)
   Cases 18 to 24

III. Hepatitis (3 cases)
   Cases 25, 26 and 27.

Few of the cases fall completely under any one heading, since a considerable amount of cholangeitis was noted in many of the cases of stone in the choledochus, while in a number of cases cholangeitis was associated with stones in the common duct. In one case hepatitis was associated with acute cholangeolitis.

RESULTS

Group I.—Cases of complete or incomplete biliary obstruction.

CASE 1.—G. H., a man aged 44, was first admitted to the hospital on Feb. 18, 1933, with a diagnosis of acute pancreatitis. He gave a previous history of attacks of heartburn for four years, associated with epigastric fulness and mild pain. Cholecystostomy was performed. The fistula drained for three months before closing. The patient was well, except for one attack of epigastric pain, until May 1934, when the attack recurred accompanied by jaundice. Operation was performed again on Feb. 13, 1934. The liver was found to be enlarged and somewhat firm. The gallbladder was not distended but showed subacute inflammation and contained rather pale, thin bile with many flocculi. There were several large, acutely inflamed lymph glands alongside the cystic duct. The choledochus was

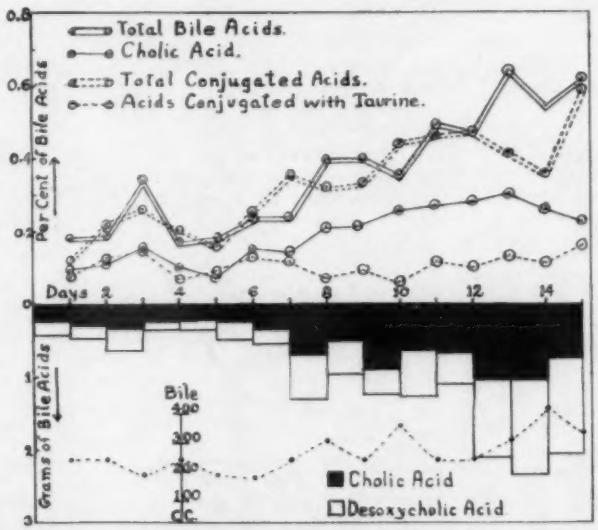

Chart 1 (case 1).—Chart showing the results of bile acids analysis after the release of complete obstruction due to chronic pancreatitis. Note the gradual steady increase both in the volume of bile and in the percentage of bile acids; the percentage of cholic acids to the total bile acids, which remains persistently about 50 per cent; the intermittent high false figures for the total conjugated bile acids, and the relatively slow increase in the taurine-conjugated bile acids.

twice the normal size and contained pale greenish bile. The entire pancreas was hard, irregular and indurated and larger than normal. A diagnosis of chronic pancreatitis with biliary obstruction was made.

Cholecystectomy and drainage of the common duct were performed. All the bile drained through the fistula. Urobilin was persistently absent from the stools. The patient was discharged with a complete biliary fistula.

The results of the analysis of bile (chart 1) exemplify clearly the recovery of bile acid by the liver after complete obstruction in the absence of an infection and without refeeding the bile. The percentage of bile acids gradually rose from 0.18 on the first day to 0.62 on the fifteenth day. The percentage of cholic acid tended to stay at about one-half that of the total bile acid content. The conjugated bile

acids formed a criss-cross pattern with the total bile acids. Apparently in the recovery phase some unknown material, probably derived from an exudate, is present in the bile. This material is soluble in alcohol and yields nonbile acid aminonitrogen. This aminonitrogen cannot be separated from the aminonitrogen released by the taurine and amino-acetic acid and so is included in the calculation for the conjugated bile acids. Consequently the calculated result yields a figure higher than the total bile acids. As the bile approached normality on the eleventh day, this excess disappeared. Especially to be noted is the relatively slow increase in taurine bile acids. By the fourteenth day the bile acids were in their normal proportions. The cholic acid content was about half the total bile acid content; the taurine bile acid content was about equal in proportion to the bile acids combined with amino-acetic acid, and a little over 20 per cent of the total bile acid content was nonconjugated. The volume of bile excreted gradually rose from 240 to 330 cc. As a result, the total amount of bile acid excreted rose from a little less than 0.5 Gm. to over 2 Gm. Daily.

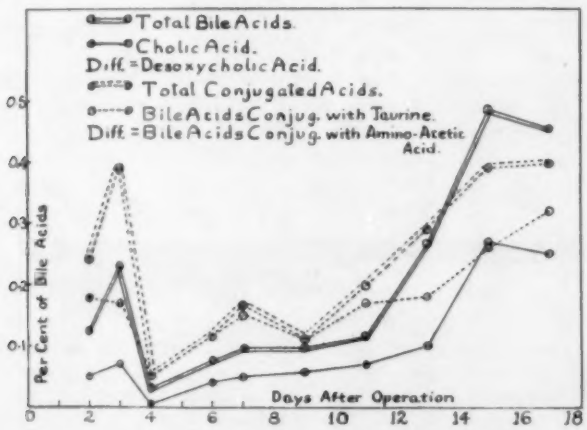

Chart 2 (case 2).—Curves showing the results of bile acid analysis in a case in which cholecystostomy was done for complete obstruction due to carcinoma of head of pancreas. Note the percentage of cholic acid, which remains persistently about 50 per cent of the total bile acid content; the high false results for conjugated bile acids up to the thirteenth day, and the sudden drop in the percentage of bile acids on the fourth day.

Case 2.—S. E., a housewife aged 58, on admission to the hospital gave a history of occasional dull pain in the right upper quadrant of the abdomen of two years' duration, a history of polydipsia, polyuria and glycosuria of six months' duration and the loss of 55 pounds (24.9 Kg.) in weight. Three weeks before operation, jaundice, light colored stools and dark urine developed. On her admission to the hospital, the edge of the liver was 7 cm. below the costal margin, the stools contained a trace of urobilin, the icteric index was 130 and the bilirubin content of the blood was 5 mg. per hundred cubic centimeters. The urine contained 3.5 per cent sugar. At operation the gallbladder was found to be subacutely inflamed and distended and to contain whitish bile and one large and several smaller cholesterol stones. The choledochus was greatly distended. Carcinoma of the head of the pancreas was found. Owing to the presence of inflammation, chole-

cystostomy only was performed. After three weeks the patient was discharged to the care of her physician.

The results of the analyses of the bile for bile acids in this case, in which complete drainage occurred through a fistula in the gallbladder, are summarized in chart 2. The sudden drop in the percentage of bile acids on the fourth day is to be noted. The percentage of bile acids gradually increased from 0.03 per cent on the fourth day to 0.45 per cent on the seventeenth day. The method of Schmidt and Dart yielded high false results up to the thirteenth day; when the percentage of total conjugated bile acids was low, from the fourth to the ninth day, the taurine bile acids, as determined from the sulfur present, masked any bile acids conjugated with amino-acetic acid that may have been present. The cholic acid content tended to maintain its ratio of 50 per cent of the total bile acid content throughout. By the fifteenth day, the proportions of the different bile acids were normal, the cholic acid forming half of the total bile acid and the conjugated

TABLE 1.—*Output of Bile Acids After Relief of Obstruction in Case 2 (Complete Diversion of Bile)*

Days After Operation	Volume of Bile, Cc.	Total Bile Acids, Percentage	Total Bile Acid Output, Gm.
2	1,020	0.12	1.22
3	1,620	0.23	3.72
4	1,200	0.03	0.36
5	1,260	....	....
6	900	0.08	0.77
7	810	0.10	0.81
8	1,380	....	....
9	1,380	0.10	1.38
10	1,040	....	....
11	600	0.11	0.66
12	570	....	....
13	480	0.27	1.29
14	360	....	....
15	540	0.48	2.59
16	360	....	....
17	540	0.46	2.48

acids four fifths of the total while the taurine bile acids were equal in proportion to the amino-acetic bile acids.

Chart 2 illustrates clearly the fallacy of using any one method for the analysis of bile acid. Thus, if the method of Schmidt and Dart alone were used, the results would be too high up to the thirteenth day and too low beyond that. By the employment of the method of Gregory and Pascoe, since it measures only cholic acid, not only would half of the total bile acids be missed, but owing to lack of sensitivity, no color would be registered up to the thirteenth day, when the percentage of cholic acid first rose to 0.01.

On analyzing the daily volume output of bile in this case (table 1), one is struck by the marked cholerrhagia during the first week. This type of severe reaction of the liver to obstruction has been noted by others.[3] The output of 3.72 Gm. of bile acids on the third day is especially to be noted.

3. Walters, W., and Parham, D.: Renal and Hepatic Insufficiency in Obstructive Jaundice, Surg., Gynec. & Obst. **35**:605 (Nov.) 1922. Bergareche, J.: La colerragia postoperatoria, signo externo de la insuficiencia hepática, Arch. de med., cir. y especialid. **36**:189 (Feb. 18) 1933.

Case 3.—M. F., a woman aged 50, had a cholecystectomy performed in 1929, after a history of disease of the gallbladder and diabetes of fifteen years' duration. She was well, except for the diabetes, for four years, when the attacks of epigastric pain recurred. At operation on Feb. 21, 1934, the common bile duct was found dilated to twice the normal size, and the liver was large, with rounded edges. No stones were found. The pancreas seemed slightly harder than normal A biopsy of the liver showed nothing abnormal. The patient died six days after choledochostomy, with a temperature of 104. F. Autopsy was not performed.

Table 2.—*Differential Bile Acid Analysis of Bile from a Fistula in Various Conditions*

Case No.	Days After Operation	Bile Acids Conjugated with: Taurine	Bile Acids Conjugated with: Amino-Acetic Acid	Total Bile Acids Conjugated	Cholic Acid	Desoxycholic Acid	Total Bile Acids	Cholic Acid, Percentage	Free Bile Acid, Percentage	Comment
3	2	0.28	0.04	0.32	0.10	0.14	0.24	42	..	Intermittent obstruction without jaundice or infection; biliary drainage; 2d day 660 cc.; 3d day, 1,260 cc.; 4th day, 1,260 cc.
	3	0.28	0.21	0.49	0.08	0.40	0.48	17	..	
	4	0.20	0.09	0.29	0.22	0.13	0.35	62	17	
4	8	0.24	0.17	0.41	0.27	0.30	0.57	47	29	Drainage from cystic duct after acute cholecystitis
5	3	....	....	....	0.19	0.18	0.37	52	..	Stone in choledochus without infection or jaundice
	9	....	....	....	0.09	0.11	0.20	45	..	
9	1	0.25	0.00	0.25	0.17	0.07	0.24	70	..	Stone in common bile duct, associated with jaundice
	3	0.21	0.00	0.21	0.05	0.20	0.25	20	16	
	4	0.12	0.00	0.12	0.04	0.04	0.08	50	..	
10	2	0.20	0.23	0.43	0.07	0.22	0.29	24	..	Ten yr. after cholecystectomy; stones in common duct without infection; slight jaundice
	4	0.15	0.01	0.16	0.04	0.04	0.08	50	..	
	5	0.11	0.00	0.11	0.03	0.00	0.03	100	..	
	7	0.07	0.04	0.11	0.04	0.01	0.05	80	..	
11	1	0.13	0.13	0.26	0.08	0.21	0.29	27	10	Hydrohepatosis; stones in choledochus with marked acute obstruction and jaundice
	5	0.10	0.00	0.10	0.08	0.00	0.08	100	..	
	9	0.05	0.00	0.05	0.08	0.04	0.12	66	54	
13	15	0.25	0.80	1.05	0.62	0.45	1.08	58	3	Drainage from cystic duct after acute cholecystitis, associated with jaundice and enlarged pancreas

Analysis of the bile acids (table 2) revealed that on the second day the cholic acid content was 42 per cent of the total bile acid content, while on the third day the ratio had fallen to 17 per cent. On both these days, however, the conjugated bile acid content was higher than the total bile acid content. On the fifth day, the percentage of cholic acid had risen to 62, and the percentage of free bile acids was 19. There was definite evidence of cholerrhagia, since the liver excreted 1,260 cc. on the third and fifth days. The cause of death, except for the indefinite diagnosis of "liver death," was not discovered.

CASE 4.—In this case cholecystectomy was performed for acute cholecystitis. The cystic duct was drained. On the eighth day, when the bile was probably normal, the cholic acid content was 47 per cent of the total bile acid content and the free bile acid content was 29 per cent of the total. The percentage of total bile acids was rather low (table 2).

CASE 5.—H. N., a housewife aged 38, was subjected to cholecystectomy in 1931 for relief from symptoms which had been present for nine years. These consisted essentially of frequent attacks of severe persistent epigastric pain, radiating to both the right and the left upper quadrant of the abdomen, to the back and to both scapulae, occurring two hours after meals and lasting from one to three hours. At operation a somewhat diseased gallbladder, containing a large number of small faceted stones, was removed. The patient was well for eleven months, when the attacks of epigastric pain recurred, unchanged except that on one occasion jaundice was present, Eighteen months after the first operation choledochostomy was performed; nothing was found to explain the symptoms. As soon as the biliary fistula closed, the attacks recurred. The patient was admitted to this hospital on June 17, 1933. All investigations gave negative results, and she was allowed to return home. After prolonged observation it was felt that the symptoms could be explained most easily by the presence of a calculus too small to cause complete obstruction or even temporary jaundice.

At operation on December 1 a small faceted calculus was found in the retroduodenal portion of the choledochus, which was not dilated. The stone was removed, and choledochostomy was performed. Convalescence was uneventful, and the patient has been well since. Analysis of two samples of the bile drained from the fistula (table 2) revealed that the cholic acid content was 52 and 45 per cent of the total bile acid content. It is to be noted that the total bile acid content was rather low, even on the ninth day.

CASE 6.—H. S., a white man aged 57, gave a history of four attacks of epigastric pain, radiating to the right upper quadrant of the abdomen and to both scapulae, during the past year. The last attack occurred twenty days before operation. Seven days later jaundice was noted. On admission, the liver was large. Bile was present in the stools and in the duodenum. The icteric index was 90. At operation on Sept. 20, 1935, the gallbladder was found thickened and distended, but it contained no stones. The choledochus was slightly dilated and contained one large stone. A probe passed easily into the duodenum. Choledochostomy was performed. The patient has been well since his discharge.

The bile acid analysis of the bile drained from the fistula (chart 3) revealed definite abnormalities. The bile drained the first day contained almost 1 per cent of bile acids, which was practically all free desoxycholic acid. The conjugated bile acid content remained low, while the cholic acid was present only in traces. The decrease in the percentage of bile acids on the fifth day is to be noted. By the tenth day, the concentration of total bile acids was slightly below 0.40 per cent, being somewhat similar to the concentration noted in cases 1 and 2 on the corresponding day.

CASE 7.—C. F., a housewife aged 60, had had attacks of gallbladder pain for five years. With the last attack, twelve days before operation, jaundice was noted. The icteric index was 50, and the bilirubin content of the blood, 2 mg. per hundred cubic centimeters. At operation the gallbladder was found to be full of stones and acutely inflamed. The common bile duct was twice the normal diameter, thickened, inflamed and full of a sandlike precipitate, but contained no stones. Cholecystostomy and choledochostomy were performed. There was evi-

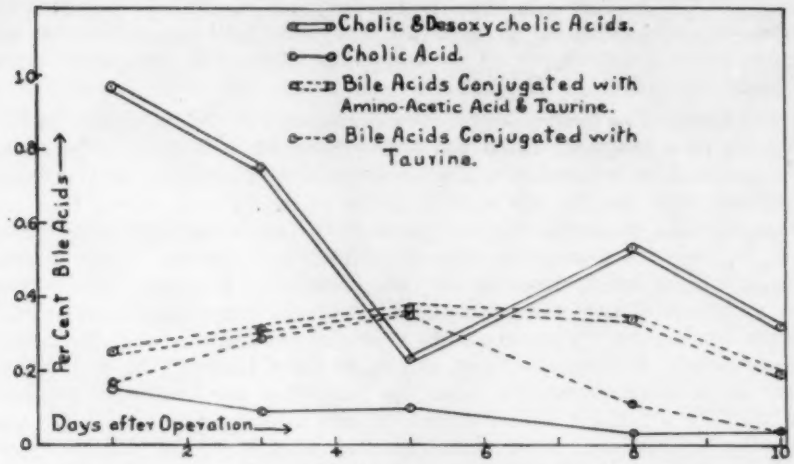

Chart 3 (case 6).—Chart showing the results of bile acid analysis in a case of intermittent obstruction of one years' duration due to a stone in the choledochus. Note the high percentage of free desoxycholic acid, the almost complete absence of cholic acid and the fall in the concentration of bile acids on the fifth day.

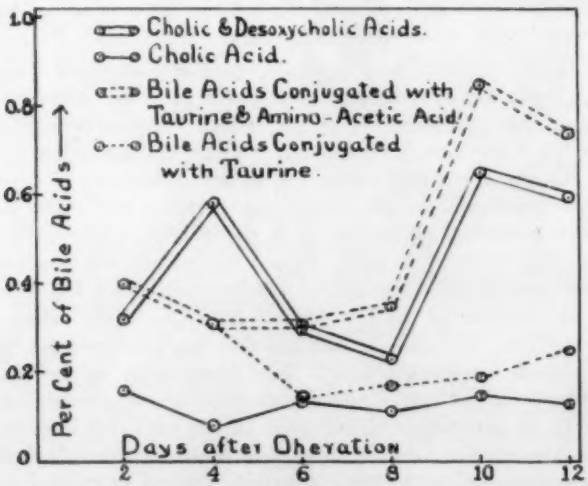

Chart 4 (case 7).—Chart showing the results of bile acid analysis in a case of acute cholecystitis, choledochitis and cholelithiasis with a sandlike precipitate in the common bile duct. Note the low ratio of cholic acid, associated with inflammation of the bile ducts, the fall in the concentration of bile acid on the eighth day as a result of excessive loss of bile through the fistula and the high false result for conjugated bile acids from the eighth day on. These false results were associated with the presence of pancreatic enzymes in the bile.

dent spasm of the sphincter of Oddi, the measurements of its resistance on the third and sixth days being 185 and 220 mm. of water. As a result, urobilin was not present in the stool until the nineteenth day.

A perusal of the bile acid analysis of the bile from the fistula (chart 4) showed a low ratio of cholic acid. To be especially noted is the excessively high false percentage of conjugated bile acids on the last six days of the analysis. During that period pancreatic enzymes were found in the bile from the fistula, apparently as a result of spasm of the sphincter of Oddi causing regurgitation of pancreatic juice.

CASE 8.—F. S., a housewife aged 61, had suffered from attacks of pain in the right upper quadrant of the abdomen for twenty years. With her last attack, twenty-four days before operation, jaundice developed. On her admission to the hospital the icteric index was 160, and the bilirubin content of the blood was 14 mg. per hundred cubic centimeters. While the patient was under observation

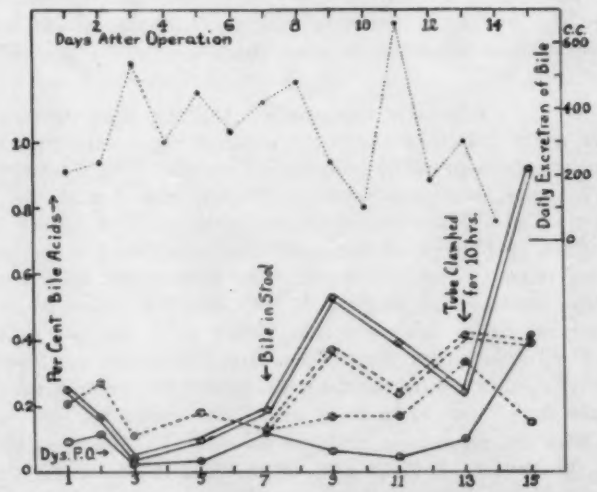

Chart 5 (case 8).—Chart showing the results of bile acid analysis in a case of chronic cholecystitis and cholelithiasis and stones in the choledochus associated with marked obstructive jaundice. Note the high false results for conjugated bile acids for the first five days, the drop in concentration on the third day, the drop in concentration on the thirteenth day following the loss of 660 cc. of bile on the previous day and the rise in the concentration of bile acids after the entrance of bile into the intestine. The various bile acids are beginning to approach their normal proportions on the fifteenth day.

the icteric index fell to 30. At operation the gallbladder was found to be thickened and full of stones. The common bile duct contained pigment stones and precipitated material and was dilated. Choledochostomy was performed. Urobilin was not found in the stool until the eighth day. The sphincter of Oddi was found to be spastic both by actual measurement and by studies made with the injection of iodized poppy-seed oil 40 per cent. On the thirteenth day after operation the tube was clamped, magnesium sulfate was given by mouth and the patient was atropinized. The next day the stool contained a large amount of bile. The tube was removed on the nineteenth day, and the patient has been well since.

A study of the secretion of bile acids in the bile from the fistula (chart 5) is of great interest, especially when correlated with the volume of biliary excretion and with the presence of bile in the stool. It can be seen that the excretion of bile acids was very low during the first seven days. A typical drop occurred on the third day. There was an excessively high amount of conjugated bile acids during the first five days. On the ninth day after the appearance of bile in the stool there was a sudden rise in the concentration of bile acids. On the eleventh day, apparently due to recurrent spasm of the sphincter of Oddi, there was a loss of 660 cc. of bile through the fistula. The next day both the volume and the percentage concentration of the bile from the fistula dropped markedly. After the clamping of the tube and the appearance of large amounts of bile in the stool, the percentage of bile acids rose to 0.92. Associated with this was the sudden drop in the excretion of bile from the fistula due to the relaxation of the sphincter of the common duct.

This case is of great significance in that it shows clearly how the entry of bile into the intestinal tract sharply raises the concentration of bile acids in the bile. The results in chart 5 should be compared with the steady and slow rise in the concentration of bile acids shown in chart 1, in which case no bile entered the intestinal tract.

Case 9.—B. S., a housewife aged 66, had suffered from diabetes for fifteen years. Eight weeks before operation she began to have attacks of biliary colic, associated apparently with slight jaundice. Two days before operation jaundice became marked, and fever was present. On her admission to the hospital the icteric index was 30, with a bilirubin content of the blood of 1.5 mg. per hundred cubic centimeters. At operation the gallbladder was found to be shrunken and to contain no stones. The choledochus was dilated and held a single large stone. Choledochostomy was performed. The tube was dislodged on the fourth day, but bile continued to drain for four weeks, up to the time of the patient's discharge. The fistula closed three weeks after discharge, and the patient has been well since. The prolonged drainage was apparently due to a spastic sphincter of the common duct, found to be so by actual measurement.

The bile from the fistula was analyzed for four days. The results (table 2) show a high proportion of cholic acid on the first day. By the third day the cholic acid content had fallen to 20 per cent, but on the fourth day it rose to 50 per cent.

Case 10.—S. S., a woman aged 48, on whom cholecystectomy was performed ten years previously, was admitted to the hospital with a history of attacks of pressing epigastric pain, associated with jaundice, of two weeks' duration. There were no chills or fever. The stools were noted to be brown, but the urine was dark. On admission the icteric index was 12, and the bilirubin content of the blood was 0.5 mg. per hundred cubic centimeters. At operation the choledochus was three times the normal size and contained two stones, one in the retroduodenal portion. After removal of the stones, choledochostomy was performed.

The results of the analysis of the bile (table 2) are abnormal. Although the cholic acid content was low in proportion on the second day, on the fourth, fifth and seventh days it was 50, 100 and 80 per cent of the total bile acid content. In all these analyses it is to be noted in addition that the amount of conjugated acids was much higher than the total bile acids content.

Case 11.—A case somewhat similar to case 10 was that of a 54 year old fireman (D. L.) who suffered from two severe attacks of epigastric pain, one six weeks and the other three weeks before operation. Jaundice was present

with the last attack. The icteric index was 85, and the bilirubin content of the blood was 7.5 mg. per hundred cubic centimeters. At operation the common bile duct was greatly distended and found to contain white bile and ten large stones. Choledochostomy was performed.

Analysis of the bile from the fistula (table 2) revealed that although the cholic acid content on the first day was only 27 per cent, on the fifth day it was 100 per cent and on the ninth day 66 per cent.

CASE 12.—T. R., a 35 year old woman, had undergone cholecystectomy six months previously at another hospital for symptoms of ten years' duration. It was noted that after the operation a biliary fistula persisted for ten weeks. Five months later painless jaundice developed. On her admission to the Mount Sinai Hospital the icteric index was 20, and the bilirubin content of the blood was 0.2 mg. per hundred cubic centimeters. Operation, performed twenty-five days

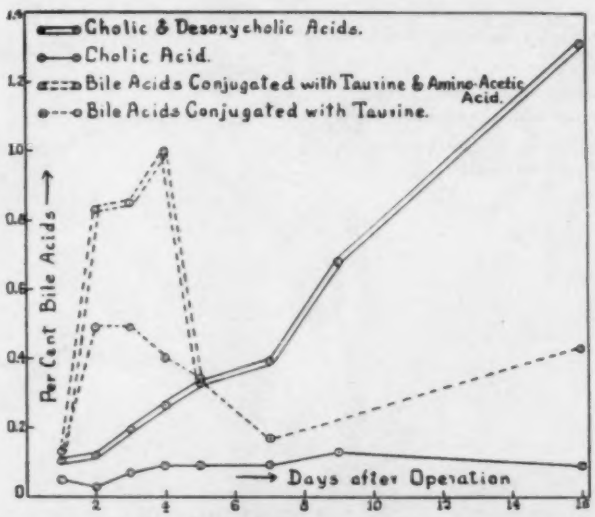

Chart 6 (case 12).—Chart showing the results of bile acid analysis in a case of stricture of the choledochus six months after cholecystectomy. Note the high false results for conjugated bile acids on the first four days, the high proportion of free desoxycholic acid, the presence of cholic acid only in traces and the presence of only taurine-conjugated bile acids after the fifth day.

after the onset of jaundice, revealed an almost complete stricture at the junction of the hepatic ducts. A tube placed in the hepatic ducts was used to achieve drainage.

Analysis of the bile (chart 6) obtained on drainage yielded abnormal results. Aside from the excessively high false results for conjugated bile acids the first four days, the extraordinary finding was the increasing excretion daily of free desoxycholic acid. Starting at 0.1 per cent on the first day after operation, by the sixteenth day the bile acid content was 1.3 per cent. The percentage of cholic acid, however, remained below 0.1 throughout. The percentage of conjugated bile acids was 0.42 on the sixteenth day. One point should be noted here as regards methods of analysis. The method of Schmidt and Dart for conjugated bile acids would have yielded high false results the first four days and excessively low results thereafter. On the other hand, by the method of Gregory and Pascoe no bile acids at all would have been found.

Case 13.—This case was one of acute cholecystitis, associated with jaundice, as a result of partial obstruction due to an enlarged pancreas. Cholecystectomy and drainage of the cystic duct were performed. Analysis of the bile on the fifteenth day revealed a concentration of total bile acid of 1.08 per cent (table 2). The cholic acid formed 58 per cent of the total bile acid content.

Case 14.—G. K., a housewife aged 51, was well for eight years after cholecystectomy. She was admitted to the hospital with a history of three attacks of severe epigastric pain, associated with vomiting, during the previous three months. While she was in the hospital, a severe attack of pain developed, associated with jaundice. The icteric index of the blood rose to 45, while at the same time the amylase content of the blood was found to be 42 units (Elman). At operation the stump of the cystic duct as well as the common bile duct was found to be dilated to 1 inch (2.5 cm.) in diameter. Two small bilirubin pigment stones

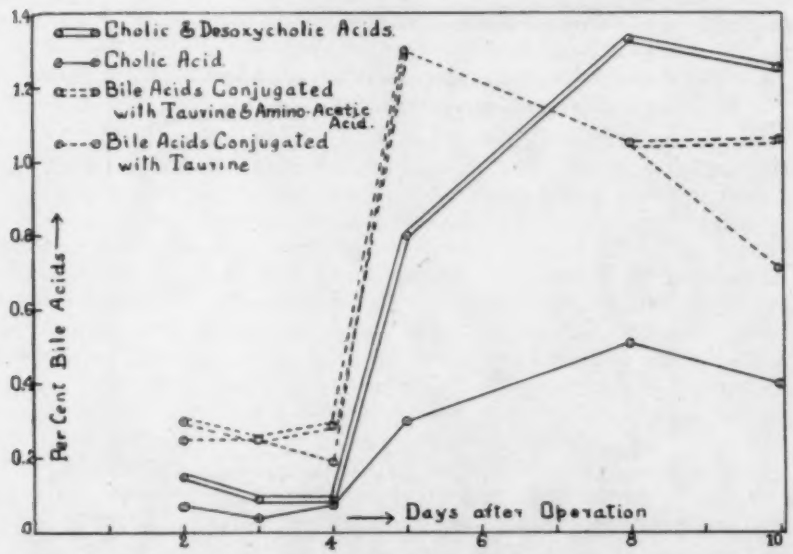

Chart 7 (case 14).—Chart showing the results of bile acid analysis in a case of acute pancreatitis associated with partial biliary obstruction eight years after cholecystectomy. Note the high false results for conjugated bile acids up to the fifth day, the high concentration of bile acids after the fifth day and the presence of the various bile acids in approximately normal proportions on the tenth day. The high concentration of bile acids in hepatic bile noted here was also present in other cases of pancreatitis.

were found in the choledochus. The pancreas was hard and enlarged, producing partial obstruction of the common bile duct. A biopsy specimen of the pancreas obtained with a punch showed acute interstitial pancreatitis and the presence of bile pigment in the fine radicles of the pancreatic duct. Choledochostomy was performed. The patient made a rapid recovery and has been well since.

Analysis of the bile from the fistula (chart 7) showed both the usual low percentage of bile acids during the first four days and also an excessive percentage of conjugated bile acids. On the fifth day, however, the bile acid content had risen to 0.8 per cent, and on the eighth day, to 1.33 per cent. On the tenth

day, the various bile acids were beginning to approach normal proportions; i. e., the cholic acid content was almost half the amount of the total bile acid, while the amount of conjugated bile acid was slightly less than the total bile acid content.

The high percentage of bile acids, in hepatic bile in cases of acute pancreatitis, as noted in cases 13 and 14, was also found in cases 15, 16 and 17 (table 3).

TABLE 3.—*Differential Bile Acid Analysis of Bile from a Fistula in Various Conditions*

Case No.	Days After Operation	Bile Acids Conjugated with: Taurine	Bile Acids Conjugated with: Amino-Acetic Acid	Total Bile Acids Conjugated	Cholic Acid	Desoxycholic Acid	Total Bile Acids	Cholic Acid, Percentage	Free Bile Acid, Percentage	Comment
15	2	....	....	....	0.26	0.11	0.37	70	..	Pancreatitis; areas of fat necrosis; distended choledochus; icterus index, 48; bilirubinemia, 3.5 mg.; 12 yr. after cholecystectomy
	5	....	....	....	0.23	0.29	0.52	44	..	
	12	0.23	0.55	0.78	0.77	0.56	1.33	58	42	
16	1	0.22	0.23	0.45	0.12	0.49	0.61	20	26	Acute pancreatitis; gallbladder and choledochus normal; no stones and no jaundice; cholecystostomy
17	1&2	0.20	0.30	0.50	0.10	1.21	1.31	8	62	Acute pancreatitis; chronic cholecystitis with one large stone; dilated choledochus
20	1-6	....	....	....	0.04	0.39	0.43	10	..	Cholangeitis; gallbladder and ducts full of precipitated pigment; fibrosis of liver
	7&8	....	....	....	0.05	0.34	0.39	12	..	
21	2	....	....	....	0.006	0.015	0.021	29	..	Cholangeitis; partial obstruction with jaundice for 4 mo.; died in cholemia on 6th day after operation
	5	....	....	....	0.016	0.274	0.290	6	..	
22	1	....	....	....	0.009	0.082	0.001	10	..	Carcinoma of papilla of Vater with obstruction; cholangeitis and pericholangeitic abscesses; died on 3d day
	2	....	....	....	0.009	0.015	0.024	37	..	
24	2	0.29	0.07	0.36	0.19	0.66	0.85	22	57	Chronic cholecystitis; dilated thickened choledochus containing one stone; incomplete obstruction; bilirubinemia, 1.2 mg.; increased number of leukocytes in periportal fields
	6	0.13	0.13	0.26	0.07	0.21	0.28	24	7	
	14	0.09	0.13	0.22	0.09	0.30	0.39	23	44	
	28	0.49	1.08	1.57	0.65	1.21	1.86	35	16	
27	1-3	0.16	0.20	0.36	0.06	0.15	0.21	28	..	Hepatic degeneration and acute cholangeolitis
	8	0.10	0	0.10	0.01	0.03	0.04	25		

In case 15 the high proportion of cholic acid on the second day is to be noted. On the twelfth day the concentration of bile acid was 1.33 per cent. In case 16 the concentration of bile acid was 0.61 per cent on the first day of drainage by cholecystostomy for acute pancreatitis. In case 17 the bile drained the first and second day had a concentration of 1.31 per cent. The cholic acid content was only 8 per cent of the total bile acid content.

Group II.—Cases in which infection of the biliary tract was predominant.

Case 18.—E. S., a woman aged 74, gave a history of attacks of pain in the right upper quadrant of the abdomen of one and one-half years' duration, accompanied by chills. She was jaundiced for three weeks before operation. The icteric index of the blood was 22, and the bilirubin content of the blood was 1 mg. per hundred cubic centimeters. There was incomplete biliary obstruction. At operation the gallbladder was found to be distended and thin walled. The choledochus measured ½ inch (1.27 cm.) in diameter and contained three large bilirubin stones. Choledochostomy was performed. Convalescence was progressing smoothly when pneumonia suddenly occurred an the twelfth day, and the patient died on the eighteenth day. Autopsy revealed bilateral lobular pneumonia of the inferior lobes. A duodenal diverticulum was present. There was marked and widespread cholangeitis.

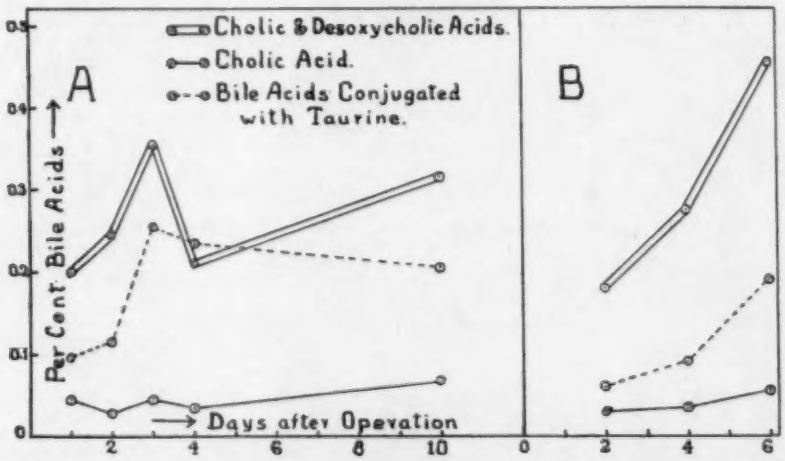

Chart 8 (case 18, 8 A and case 19, 8 B).—Chart showing the results of bile acid analysis in a case of widespread cholangeitis. Note the low ratio of cholic acid, the presence only of taurine-conjugated bile acids and the high proportion of free bile acids in B.

The results of the bile acid analysis of the bile from the fistula (chart 8 *A*) are typical of those in cases of cholangeitis. It is to be noted that the proportion of cholic acid to the total bile acids remains consistently low, and that the conjugated bile acids are expressed wholly as taurine bile acids owing to the fact that the aminonitrogen, as calculated from the sulfur present, was found to be as high or higher than the total aminonitrogen, as determined by the gasometric procedure of Van Slyke.

Case 19 (chart 8 *B*).—Analysis yielded results similar to those in case 18. Fibrosis of the liver was noted, and a biopsy specimen obtained by means of a punch revealed a marked exudate of polymorphonuclear and lymphocytic cells in the periportal fields. A cyst was found in the choledochus. The drainage of bile from the common duct revealed Bacilli coli on culture. Although the total bile acid content rose to 0.45 per cent on the sixth day, only a trace of cholic acid was present throughout. Only taurine-conjugated bile acids were found.

CASES 20, 21 and 22.—These cases are similar examples of cholangeitis. In case 20 operation for subacute cholecystitis associated with jaundice revealed the gallbladder and ducts to be full of precipitated pigment. The liver appeared to be fibrosed. The cystic duct was drained. As can be seen in table 3, analysis of the bile revealed a low proportion of cholic acid. In case 21 operation revealed a shrunken gallbladder. A stone impacted in the cystic duct protruded into the choledochus and caused partial obstruction, which had produced slight jaundice for a period of four months. Cholangeitis was present. Choledochostomy was performed. The patient died on the sixth day in cholemia. The bile was pale and thin, and, as can be seen in table 3, analysis on the first day revealed only a trace of bile acids. On the sixth day, before death, the bile acid consisted almost wholly of desoxycholic acid.

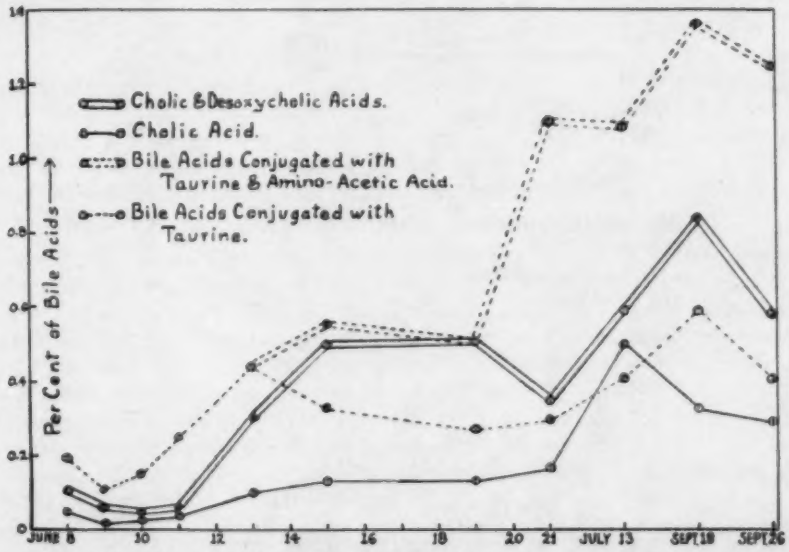

Chart 9 (case 23).—Chart showing the results of bile acid analysis in a case in which choledochostomy was performed for acute cholangeitis, which occurred four months after cholecystectomy and removal of a stone from the common bile duct. Note the low cholic acid ratio up to the time when the inflammation in the bile ducts was overcome, the high cholic acid ratio on July 13 after the closure of the tube for several days, and the high false results for the conjugated bile acids persisting after disappearance of the inflammation. These results were associated with the presence of pancreatic enzymes in the bile.

Case 22 (table 3) represents the results of an analysis of bile acids in a 48 year old man who at operation was found to have a carcinoma of the papilla of Vater with complete obstruction. Cholecystostomy was performed. On the first day 870 cc. of dark, concentrated-looking bile was drained, while on the second day 1,770 cc. of bile was collected. The patient died three days after operation. At autopsy acute cholangeitis and pericholangeitic abscesses were found. The bile, although very dark, was found to have only a trace of bile acids.

CASE 23.—F. J., a housewife aged 49 years, first had attacks of pain in the right upper quadrant of the abdomen in January 1934. In July 1934, jaundice

and pruritus developed, and the stools were clay colored. In October 1934, choledochostomy and cholecystectomy were performed. After removal of a stone from the common bile duct she was well for three months, when symptoms of epigastric pain, chills, fever, vomiting, icterus and pruritus recurred. She was admitted to this hospital, and operation was performed on June 8, 1935. The choledochus was found to be dilated and thickened and containing infected bile full of inspissated material. Culture yielded a growth of B. coli. Biopsy of the liver showed only slight thickening of the periportal fields. A T-tube was inserted, and drainage was carried out for fourteen weeks. During the latter ten weeks the tube was closed off for sixteen hours every day. It was finally removed, and the fistula closed in two days. The patient remained well for five weeks, when the whole train of the original symptoms recurred. Reoperation was performed on Dec. 4, 1935. Severe cholangeitis was again found, and in addition biopsy of the

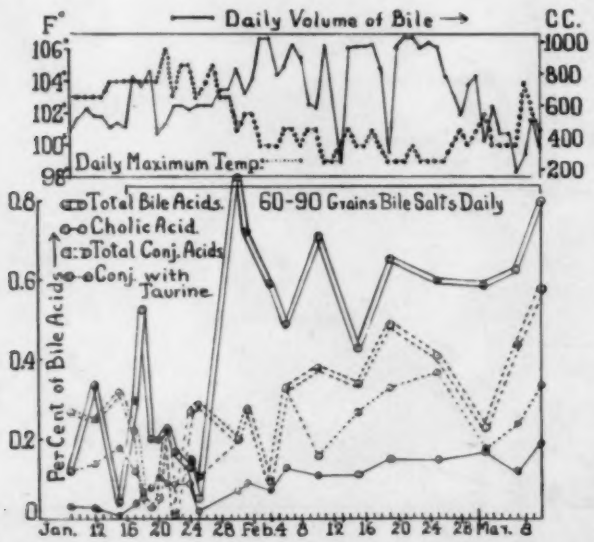

Chart 10 (case 23).—Chart showing a summary of the bile acid analysis starting one month after reoperation for recurrence of cholangeitis and cholangeolitis. Note the low concentration of bile acids in association with cholangeolitis (January 9 to 24), the effect of feeding large amounts of bile salts by mouth, the concentration rising from 0.2 to 0.8 per cent and the volume of bile increasing from 600 to 1,000 cc. daily and the persistently low ratio of cholic acid. Note also that as the fever increases the volume of bile falls.

liver showed widespread chronic pericholangeolitis. Since the operation bile has continued to drain, and the patient has slowly been getting worse. Bouts of high fever have recurred. Drainage has been kept up continuously through the tube.

Chart 9 summarizes the bile acid analysis of the bile from the fistula after the first operation. It can be seen that during the first weeks the proportion of cholic acid was typically low in proportion to the total amount of bile acids, as in other cases of cholangeitis. The conjugated acids tended to be higher than the total bile acids. Isolated analyses during the next three months, when the patient

was apparently well and the bile was clear, indicated that the cholic acid was in normal proportion. On July 13, however, cholic acid was 85 per cent of the total. This analysis was done shortly after the tube had begun to be clamped off daily. One extraordinary finding can be noted especially. The analyses performed after June 21 showed a high false result for the conjugated bile acids, although the cholic acid ratio was in normal proportion.

After the second operation the bile acid analysis of the drainage material (chart 10) was carefully followed, especially in relation to the temperature curve, the volume output of bile and the effect of oral administration of large amounts of pure bile salts. The bile salts were given both to improve the nutrition of the patient by increasing absorption from the intestinal tract and to increase the excretion of bile in an attempt to flush out the infection. As can be seen from the chart, the bile salt therapy was begun over one month after the second operation. During that period the patient had a consistently high intermittent fever, and the fistula drained daily from 60 to 120 cc. of bile containing a low percentage of bile acids. With the administration of bile salts, the volume output of bile acids rose markedly. But it is to be noted that when the temperature rose the volume of bile tended to diminish, although the percentage of bile acids stayed up. The bile acid analysis shows the consistently low ratio of cholic acid to total bile acids, in spite of the fact that the bile salts given orally contained about 80 per cent of cholic acid. In addition, the excreted bile acids were preponderantly in the form of free bile acids.

Case 24.—J. J., a salesman aged 44, first had severe attacks of right subcostal pain seven months previous to his admission to this hospital. The attack persisted for three weeks. At the same time he was found to have diabetes. He had four similar attacks afterward, the last one occurring four days before admission. The last two attacks were accompanied by fever, the temperature rising to 101 F., and icterus. On the patient's admission the icteric index was 9, and the bilirubin content of the blood was 1.2 mg. per hundred cubic centimeters. Urobilin was present in the stool. Before operation the icteric index had fallen to 5 and the bilirubin content of the blood was 0.4 mg. At operation the gallbladder was found to be shrunken and thickened. An old perforation into the bed of the liver was present, where stones were found. The choledochus was markedly thickened and dilated to 1 inch (2.5 cm.) in diameter. A cholesterol stone was found in the retroduodenal portion. Cholecystectomy and choledochostomy were performed. Biopsy of a specimen from the liver revealed a conspicuous number of bile thrombi and an increase in the number of leukocytes in the periportal fields. The choledochostomy T-tube was clamped on the twenty-second day. After six days the tube was opened, a sample of bile was obtained and the tube was removed. Convalescence was uneventful, and the patient has been well since.

This case is added not only to demonstrate the low cholic acid ratio in cases of cholangeitis and cholangeolitis, but also to present an analysis of a fairly normal sample of hepatic bile (table 3). Thus when the tube was clamped off for six days the enterohepatic cycle was completely reestablished, and a sample of normal bile could then be obtained by tapping the tube. When the tube was opened for a short period, the sample of bile obtained had bile acid in a concentration of 1.86 per cent, of which 35 per cent was cholic acid. The slightly low cholic acid ratio may have been due to some residual infection in the biliary tract. The indications are that approximately normal hepatic bile contains almost 2 per cent bile acids.

GROUP III.—*Cases of acute hepatitis.*

CASE 25.—F. R., a 57 year old woman, had a feeling of epigastric distention three weeks before operation. One week later pruritus and marked jaundice occurred. At operation a large, smooth liver and an enlarged spleen were found. The gallbladder and extrahepatic bile ducts were empty of bile and were very edematous. Cholecystostomy was performed. A biopsy specimen of the liver showed acute hepatitis. Small amounts of dark bile drained for a short time. The jaundice decreased rapidly, and the patient was discharged as well.

The bile acid analysis (chart 11) showed a high concentration of free bile acids the first few days and especially a high proportion of cholic acid, apparently characteristic of hepatitis. The rapid fall in the concentration of bile acids was probably due to absorption of the bile acids from the inflamed gallbladder as a result of irritation of the drainage tube.

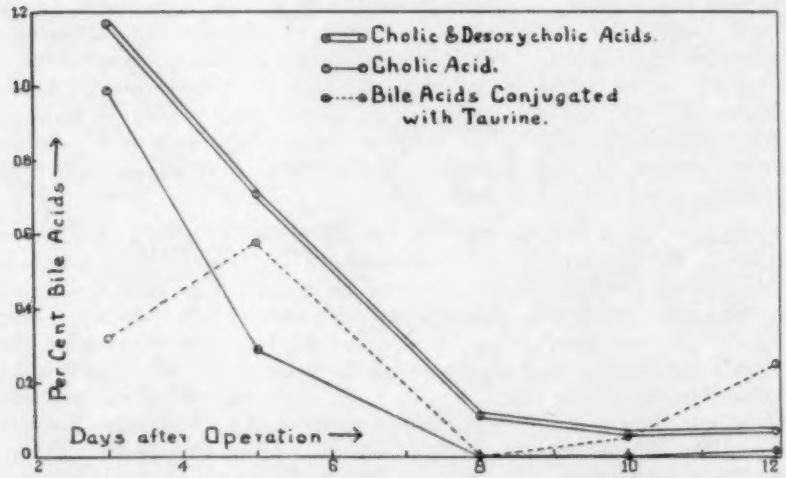

Chart 11 (case 25).—Chart showing the results of bile acid analysis in a case of acute hepatitis in which cholecystostomy was performed. Note the high concentration of bile acids at the onset of drainage and their disappearance after the first day; especially to be noted is the high cholic acid ratio at the onset of drainage and also the presence of taurine-conjugated bile acids only.

CASE 26.—F. W. F., a housewife aged 44, began to suffer from attacks of epigastric pain radiating to the back three years previously. Six months before her admission to the hospital marked weakness and severe pruritus developed. She was admitted to the Mount Sinai Hospital, and a thorough investigation was made. Nothing abnormal was discovered except rather marked anemia and achlorhydria. Two weeks after her discharge mild jaundice developed, which was at first intermittent but more recently increased slowly. The stools became light in color, and the urine very dark. The patient began to lose weight. There was no fever or chills, but chilly sensations were noted occasionally. Pruritus became severe.

The liver was enlarged, smooth and very tender. The spleen was not palpable. The icteric index was 50. At operation the gallbladder was found to be normal,

being neither distended nor dilated. The common duct was not dilated. The liver was large and smooth. A biopsy of the liver showed acute interstitial hepatitis. Choledochostomy was performed.

The results of the bile acid analysis (chart 12) are very similar to those in case 25. The first two days the total percentage of bile acids was quite high but subsequently fell to zero (on the seventh day) and then rose again. The ratio of cholic acid was very high on the second day (81 per cent of the total bile acid content) and then fell to 63 per cent on the third day and 44 per cent on the fifth day. On the tenth day the ratios of the different bile acids were beginning to approach normality.

CASE 27.[4]—S. C., a white man aged 48, was admitted to the Hospital for Joint Diseases with a history that for three weeks he had attacks of pain in the

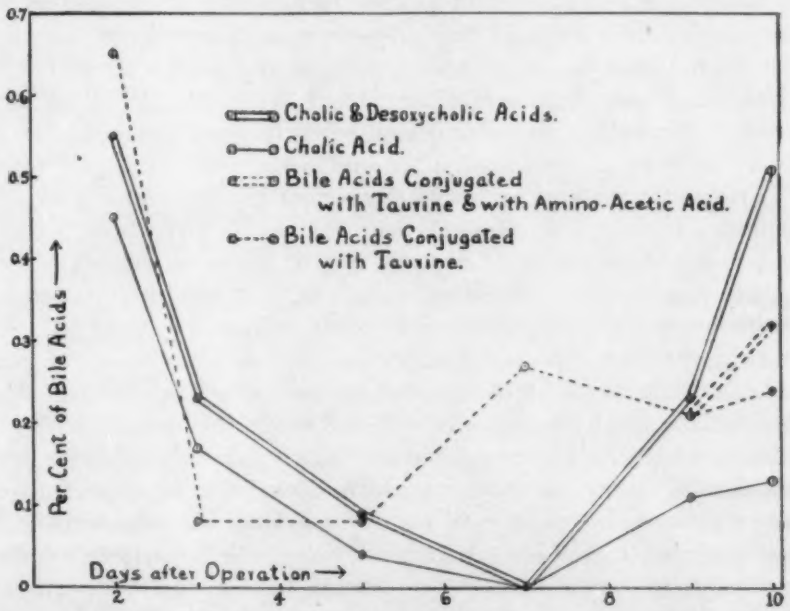

Chart 12 (case 26).—Chart showing the results of bile acid analysis in a case of acute interstitial hepatitis in which choledochostomy was performed. Note the high concentration of bile acids at the onset of drainage, the fall to zero on the seventh day and the rapid rise on the tenth day, the high cholic acid ratio during the first few days of drainage, and the presence of the various bile acids in almost normal proportions by the tenth day.

right upper quadrant radiating to the back, lasting from one to two hours and accompanied by vomiting. There were no chills. The pain became continuous; there were progressive jaundice, clay-colored stools and dark urine. There was a loss in weight of 14 pounds (6.4 Kg.). On his admission to the hospital, however, the patient, although highly icteric, looked well nourished. The liver was enlarged 4 fingerbreadths below the costal margin and was tender to pressure. The spleen could not be palpated. The icteric index of the blood

4. Presented by permission of Dr. A. J. Beller and Dr. H. L. Jaffe.

was 120. At operation bile-stained fluid was found in the peritoneal cavity. Acute cholecystitis and hepatitis were present. The gallbladder and common duct were not distended and contained no bile. Choledochostomy was performed. A biopsy specimen of the liver revealed the presence of both widespread degeneration of the liver cells and severe cholangeitis and pericholangeitis. After a stormy course, the patient was discharged well.

Analysis of several specimens of bile obtained by drainage revealed a low percentage of total bile acids, of which the cholic acid formed 25 per cent.

COMMENT

At the onset, one should emphasize that all the laboratory findings should be interpreted with great caution because they are based on material in which several varying factors may be present in any one case. Our concept of the proportions of the different bile acids in normal bile is based on scanty material and on bile from fistulas, which fundamentally must be considered abnormal. It is for these reasons that such a large series of cases is presented and that the history of most of them is given in some detail.

Frequent references are made throughout this presentation to other methods of analysis as compared with the results given here. This is done to emphasize the point that any single method of analysis is often open to large errors. The interpretation of such results as reported in the literature must be accepted with great caution.

In a previous report it was shown that in many cases of acute cholecystitis, analysis of the bile by the method of Schmidt and Dart gave results which were much higher than the amount of bile acids actually present. These excessively high and false results were undoubtedly due to the presence of an alcohol-soluble aminonitrogen-containing material which was not derived from the bile acids. The most probable source of this material was the inflammatory exudate. In most of the cases presented here it can be seen that both after the release of obstruction and in the presence of inflammation of the bile ducts the same type of result is found. During the first few days the conjugated bile acids, as estimated by the hydrolyzable aminonitrogen, are frequently found to be much higher than the total bile acids actually present. It would seem that in the bile from a fistula also the presence of any inflammatory exudate would best explain the false results obtained by the method of Schmidt and Dart.

In addition it is to be noted that in these cases the conjugated bile acids appear as mostly conjugated with taurine. This result is undoubtedly due to the presence in pathologic bile of alcohol-soluble sulfur compounds which are included in the sulfur determination used to estimate the taurine. As a result, the excessively high figures for sulfur mask the presence of any bile acids conjugated with amino-acetic acid which may be present.

In several instances, notably in cases 7 and 23 (charts 4 and 9), excessively high figures for conjugated bile acids were obtained after prolonged drainage. In both of these cases, pancreatic enzymes, apparently due to reflux of pancreatic juice, were found in the bile. The high figures for conjugated bile acids could then be explained as due to the splitting of protein into alcohol-soluble aminonitrogen-yielding material. Similar results are obtained on analyzing bile drained from the duodenum. Even if analyzed immediately, such material will yield higher results for the conjugated bile acids than for the total bile acids. In addition, the longer the material is allowed to stand the higher will be the figures for the conjugated bile acids. Thus, a sample of duodenal bile was divided into portions. One portion was analyzed immediately, while the other was allowed to stand for twenty-four hours at room temperature. The results were as follows:

	Immediate Analysis, Per Cent	After 24 Hours, Per Cent
Bile acids conjugated with taurine	0.16	0.16
Bile acids conjugated with amino-acetic acid	0.53	0.90
Total conjugated bile acids	0.68	1.06
Cholic acid	0.16	0.16
Desoxycholic acid	0.31	0.32
Total bile acids	0.47	0.48

It is to be noted that although the results of the analysis of sulfur, which were used to calculate the taurine-conjugated bile acids, remained unchanged, the percentage of total conjugated bile acids rose markedly. The amounts of cholic and desoxycholic acids were found to be unchanged after twenty-four hours. The only explanation for these changes must be that the pancreatic enzymes hydrolyzed a portion of the protein present, and so formed alcohol-soluble nitrogenous material.

It is difficult to account for the sudden drop both in the volume of bile and in the percentage of bile acids that occurs in most cases between the third and the fifth day. Two explanations are possible. One is that the inflammatory reaction of the choledochus after operative trauma results in the absorption of a part of the bile acids. The other and more likely explanation is that after the release of obstruction the bile acids present in the fine bile ducts throughout the liver are washed out during the first two or three days. The liver itself, as a result both of the obstruction and of the operative trauma, begins to manufacture bile acids only after several days. The concentration of bile acids in the hepatic bile then increases gradually. Cases 1 and 2 are good examples of the gradual functional recovery of the liver.

It is a difficult matter to form some estimate as to the proportions of the various bile acids in normal bile. It is evident that after a few

days of drainage (as in cases 1, 2, 3, 4, 5, 8, 13, 14 and 15) the various bile acids tend to be present in definite proportions. The cholic and desoxycholic acids tend to be in equal proportions, and the percentage of taurine-conjugated bile acids is about one-half the total conjugated bile acid content, which in turn form about 80 per cent of the total bile acid content. In a previous report on the bile acid composition of bile from the gallbladder, somewhat similar findings were noted in cases in which the gallbladder was normal.

On analyzing the results of the whole series of cases, the variations in the ratio of cholic acid to desoxycholic acid seem to be the most important findings (chart 13). Essentially it can be seen that

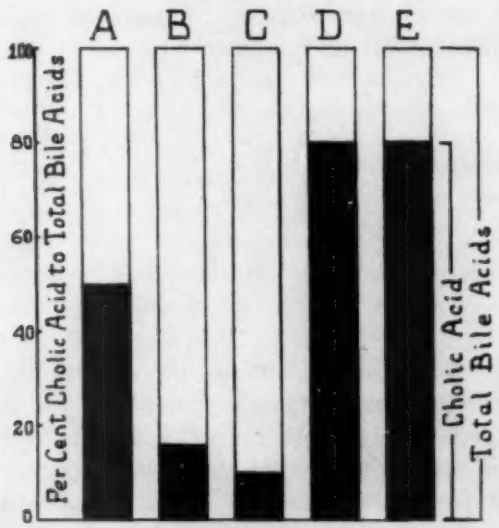

Chart 13.—Summary of findings of the ratio of cholic acid to total bile acids in the bile drained through a fistula in various conditions. In *A*, the cholic acid forms approximately one half of the total bile acid content in apparently normal bile; in *B*, widespread cholangeitis, only about one sixth of the total bile acid content is found to be cholic acid; in *C*, long-standing intermittent biliary obstruction, only about one tenth of the total bile acid content is cholic acid; in *D*, acute obstruction, cholic acid forms about four fifths of the total bile acid content, and in *E*, acute hepatitis, about four fifths of the total bile acid content is cholic acid.

after the release of noninflammatory obstruction the percentage of cholic acid to the total bile acid content appears to be about 50. Cases 1, 2, 3, 4, 5, 8, 13, 14 and 15 are examples. In cases in which inflammation of the bile ducts is the predominating factor the cholic acid invariably forms a very low percentage of the total bile acids. Cases 18 and 19 (chart 8), cases 20, 21 and 22 (table 3) and case 23,

after the first operation (chart 9) until the infection cleared up, and throughout the period after the second operation (chart 10), are all examples of such conditions. In cases in which hepatitis was the predominating pathologic condition the cholic acid tended to form a high proportion of the total bile acids. Cases 25 and 26 (charts 11 and 12) are good examples illustrating the results of analysis of such conditions. The extraordinarily high percentage of bile acids after drainage during the first three or four days in such conditions is a noteworthy finding. It seems most likely that this large concentration of bile acids must be due to the washing out of the bile passages as a result of drainage. In case 26 (chart 12) the bile acids were in the normal proportions by the tenth day. It is evident that in this case the operative procedure in a case of acute hepatitis not only had done no harm but actually seemed to have hastened the onset of recovery. As a matter of fact, in all three cases of hepatitis presented here the operative procedure was apparently beneficial. French observers have reported similar good results.[5]

Certain exceptions to the foregoing findings must be made. In case 7 (chart 4) both obstruction due to stone and cholangeitis were present. It can be noted that the ratio of cholic acid was low throughout, typically that seen in cholangeitis. In case 6 (chart 3) and in case 12 (chart 6) the most notable feature is the extraordinary high percentage of free desoxycholic acid. In both cases there was a history of long-continued intermittent obstruction. In case 6, as a result of obstruction by stone, and in case 12, as a result of stricture, these findings of the very low percentage of cholic acid and of the very high percentage of free desoxycholic acid may be due to injury to the liver cells as a result of the long-continued intermittent obstruction. In a number of cases in which there was sudden acute obstruction without infection an opposite condition was present. Cases 9, 10 and 11 (table 2) are examples. Here the percentage of cholic acid tended to be high, sometimes 70, 80 or 100 per cent of the total. In all these cases there was sudden acute obstruction associated with jaundice. The gallbladder in these cases was absent or shrunken and fibrosed, so that its action as a safety valve was absent. As a result, in sudden acute obstruction the brunt of the back pressure would be borne by the liver cells themselves. Case 23 (chart 9, July 13) is an example of the results of an acute obstruction. In this case there had been long-continued drainage through a T-tube for one month. On July 10 the patient had begun to tie up the tube for a period of sixteen hours each day. Analysis of the bile on July 13 showed that the cholic acid

5. Chabrol, E.; Brocq, P., and Porin, J.: Les enseignements de la cholécystostomie dans les ictères infectieux, Presse méd. **40**:1053 (July 6) 1932.

instead of being 50 per cent of the total bile acid content had risen to 83 per cent of the total. This sudden rise was apparently due to acute obstruction after the closure of the tube in a case in which the sphincter of the common duct was spastic. That acute injury to the liver cells may be the cause of a high cholic acid ratio is supported by the evidence found in cases of acute hepatitis (cases 25 and 26). In these cases it was evident on histologic examination that there was widespread injury to the liver cells, and here also the cholic acid ratio was very high.

In cases in which there was associated pancreatitis (case 13, table 2; case 14, chart 7; cases 15, 16 and 17, table 3), one outstanding point is to be noted, viz., the percentage of bile acid tended to be very high. In case 13 the bile contained 1.08 per cent of bile acids on the fifteenth day. In case 14 (chart 7) the bile contained 1.35 per cent of bile acids on the eighth day. Similar high percentages of bile acids were found in cases 15, 16 and 17 (table 3). These findings are of great interest in the relation to the point of view held by many investigators that acute pancreatitis is often due to regurgitation of bile into the pancreatic duct. That this theory is correct is supported by our finding in case 14 of bile-filled ducts in a biopsy specimen of pancreas removed at operation. It is evident that if a reflux of bile causes pancreatitis, such an event can occur only if the bile contains a high percentage of bile acids, since it was shown long ago by Flexner [6] that the important toxic element in bile is the bile acids. The finding of a high concentration of bile acid in the hepatic bile in all our cases of pancreatitis is strong evidence in support of the view that in many cases pancreatitis is produced by the reflux of bile into the pancreatic ducts.

The analyses in case 27 form a good example of the results produced when a combination of two factors is present. In cases of cholangeitis the cholic acid forms about 15 per cent of the total bile acid content. In cases of hepatitis cholic acid forms about 80 per cent of the total bile acid content. In case 27 both conditions were present at the same time, and the cholic acid was found to be 28 and 25 per cent of the total bile acid content.

The low cholic acid ratio found in all cases of inflammation of the bile ducts requires close consideration. In a previous paper it was shown that in cases of acute cholecystitis with obstruction of the cystic duct the bile acids were absorbed in a differential manner. The more prolonged the obstruction, the lower the cholic acid ratio fell, indicating that the cholic acid was absorbed much more readily than the desoxycholic acid. Since in cases of acute cholangeolitis the bile flows

6. Flexner, S.: The Constituent of the Bile Causing Pancreatitis and the Effect of Colloids upon Its Action, J. Exper. Med. **8**:167 (Jan.) 1906.

through innumerable fine bile canaliculi, there is a strong possibility that the bile acids are absorbed by the inflamed walls of the ducts. The finding of a low cholic acid ratio in a case of acute cholangeitis supports this theory. Chart 10 (case 23) presents a summary of a typical case of widespread cholangeolitis followed in great detail. As can be noted, the volume of bile decreases as the temperature rises and increases as the temperature falls, indicating that during the more acute phases of inflammation more bile was absorbed. Even the bile that was excreted contained only a low percentage of bile acids. The same is found in other cases of cholangeitis (cases 20, 21 and 22). When bile acids were fed in large amounts (from 60 to 90 grains daily [3.9 to 5.8 Gm.]) the cholic acid ratio remained persistently low despite the fact that the bile acids administered contained 80 per cent of cholic acid. It is evident that the bile acids were absorbed from the intestine and excreted by the liver, but during their passage down the bile ducts it appears that the cholic acid was absorbed much more readily than the desoxycholic acid, which was excreted partly as free and partly as conjugated acid. Another point indicating that bile was absorbed from the inflamed bile ducts was the appearance of bile pigment in the urine every time the temperature rose and the volume of bile decreased. This occurred in spite of the fact that there was no obstruction and bile was being excreted in large quantities. It would seem, therefore, that in cholangeolitis both bile salts and the bile pigment are absorbed by the inflamed walls of the bile ducts.

CONCLUSIONS

1. After the release of obstruction uncomplicated by infection the cholic acid of hepatic bile forms about 50 per cent of the total bile acid content.

2. In the presence of inflammation of the bile ducts, cholic acid forms about one sixth of the total bile acid content. This low cholic acid ratio indicates that the bile acids are probably absorbed by the inflamed bile ducts.

3. In cases of acute obstruction of the biliary tract in which the gallbladder is absent cholic acid forms about four fifths of the total bile acid content.

4. In cases of acute hepatitis cholic acid forms about four fifths of the total bile acid content.

5. In all cases of pancreatitis presented here, the hepatic bile was found to contain a high percentage of bile acids.

A REVIEW OF UROLOGIC SURGERY

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(Concluded from page 1116)

TRANSURETHRAL SURGERY

Thompson,[36] in a report concerning transurethral operations performed at the Mayo Clinic during 1935, called attention to the use of sodium ethyl-1-methylbutylthiobarbituric acid in producing anesthesia. This drug is injected intravenously and seems unusually well suited to urologic practice. This anesthetic is suitable for cystoscopic examinations, manipulation of ureteral stones, removal of vesical tumors, litholapaxy and transurethral prostatic resection, in fact for almost any type of transurethral procedure which can be completed within thirty minutes.

During the year 63 patients with neoplasm of the bladder were treated by transurethral methods, involving destruction by electrocoagulation or excision of the growth with either an operating cystoscope or the Stern-McCarthy resectoscope. Until a few years ago the

36. Thompson, G. J.: Transurethral Surgery in 1935, Proc. Staff Meet., Mayo Clin. **11**:360-363 (June 3) 1936.

transurethral destruction of all but very small vesical neoplasms involved repeated cystoscopic treatments which often extended over a period of several weeks or months. At present practically any pedunculated growth can be removed in one sitting. Those tumors which infiltrate the wall of the bladder should, of course, be removed suprapubically. However, in a number of cases of this type the general condition of the patient precluded major operation, and therefore radon emanation seeds were implanted through the cystoscope.

Thirty-three patients were subjected to 39 operations in an attempt to remove calculi from the ureter. In 25 of these cases the stone was removed at the time of manipulation, in most instances with the Councill stone extractor. This instrument must be used carefully, or severe injury to the ureter and a serious postoperative reaction will ensue. In 5 additional cases the stone was passed a few days or a week after manipulation with little discomfort to the patient. The transurethral method was therefore successful in more than 90 per cent of the cases.

There were 695 patients who had urinary obstruction due to benign or malignant involvement of the prostate gland on whom a total of 765 prostatic resections were performed. Attention is called to the fact that 35.4 per cent of these patients were more than 70 years of age, and only 7 per cent were less than 55 years of age. These figures are contrasted with those for a group of 1,922 patients who were accorded prostatectomy prior to 1932, of whom 20.4 per cent were more than 70 years old, indicating that a considerable number of elderly men who formerly refused or were denied prostatectomy are presenting themselves and are being referred for transurethral resection. Thompson expressed the belief that transurethral resection can be done safely at any time when the volume output of urine is more than 1,500 cc. daily and the patient is free from fever. No attempt was made during the year to reduce the degree of pyuria to a minimum prior to operation. It was felt that the urinary infection could be more easily dealt with after the patient was able to empty the bladder by normal urination. This change in attitude concerning the necessity of preoperative preparation has resulted in a still shorter stay in the hospital and consequently less expense for the patient. The average postoperative stay in the hospital for the entire group was eight and three-tenths days.

There was no mortality from any of the transurethral procedures (a total of 2,851 procedures on 1,521 patients) except in the group of patients undergoing prostatic resection. Of the 695 patients who were subjected to transurethral resection, 7 died, a mortality of approximately 1 per cent.

PROSTATE GLANDS

Prostatitis.—Grant [37] in 1933 stated that the etiology of prostatitis is due to the gonococcus in from 75 to 90 per cent of cases. Whatever the original cause, in a very short time the cultures of the expressed prostatic secretion reveal mainly growths of Staphylococcus albus and Bacillus coli. The termination of acute prostatitis is resolution or the development of abscess, or chronic prostatitis. The structure of the prostate gland, with its multitude of ramifications of acini, gives deep-seated pockets to the invading organisms, the path of approach of which in most cases undoubtedly is along the mucus-lined passages from the posterior portion of the urethra. Almost all methods of treatment are bent toward the reverse of this march by promoting the flow of infected material outward into the urethra again. Treatment by diathermy tends to increase the flow from the infected pockets by heating the gland and by improvement of the circulation. Massage is done for the purpose of pushing the infection out and somewhat as a stimulation to the circulation. Grant stated that, considering the pathologic anatomy, little can be accomplished by massage except to empty a few overdistended acini, and many must be pressed in more tightly. The incidence of epididymitis following massage is too frequent to recall with pleasure.

The treatment of prostatitis from a systemic base has been advocated by many proponents of treatment with foreign serums. Young, Colston and Hill have treated some patients by the intravenous injection of a solution of mercurochrome. Grant stated that it seems impossible to apply any medication to the interior of the prostate gland through the urethra. Lavage of the urethra can only affect the mouths of the prostatic ducts and can accomplish little as a cure. He recalled that Townsend, in 1917, in collaboration with Valentine and Cano, suggested a method of treating the gland by intraprostatic injections of solution of methylphenol and a normal phenol serum. Grant concluded that since mercurochrome was nontoxic and nonirritating a good plan would be to inject the solution into the interior of the gland with the reasonable assurance that the antiseptic would then come in direct contact with the infectious organisms. His technic is to fill the bladder with water and then introduce a 6 inch (15.24 cm.) 22 gage needle through the perineum into the prostate gland, guiding the needle with a finger in the rectum. From 10 to 20 cc. of solution of mercurochrome is injected at various points throughout the gland, and gentle massage follows to disseminate the drug. Grant stated that there is little pain from the injection. The patients complain of a sense of distention in the prostatic region, which is immediately relieved by voiding. He stated

37. Grant, Owsley: Treatment of Prostatitis by Injection, J. Urol. **29**:749-753 (June) 1933.

that the first hundred patients were selected because they had chronic prostatitis without evidence of disease of the vesicles. Since then he frequently accompanies the procedure of intraprostatic injection with vasopuncture and injections of mercurochrome through the vas. He stated that 400 patients have been so treated without a single untoward result. Grant is of the opinion that the end-results he obtains by this method are most satisfactory.

Grant,[38] in 1935, stated that the early steps in the treatment of chronic prostatitis by injection should be taken with exquisite care. First he "injected a few dogs' glands and they seemed none the worse"; then he hospitalized 25 patients for a week after injection, and no untoward symptoms developed; then he had 50 ambulatory patients make a report daily. The latter had no distress. He stated that in 500 cases he never had any cause to question the complete safety of the procedure. In some cases the drug was undoubtedly partially injected outside the capsule without any deleterious effect. Patients with chronic prostatitis received the most benefit. No conclusive data have been available for study of resultant pathologic changes. No sexual disturbance was complained of. At the time of perineal injection into the prostate gland, both vasa are injected with 10 cc. of a 1 per cent aqueous solution of mercurochrome. The average injection directly into the prostate is 20 cc. (10 cc. into each lateral lobe) of a 1 per cent solution of mercurochrome. After injection the gland is massaged by rectum to disseminate the fluid through the gland. The urethral method of injection is accomplished with a specially constructed needle through a McCarthy panendoscope under direct vision. The follow-up treatment consists of heat applied to the gland and massage every fifth day. The usual course of the latter lasts about from three to five weeks after operation, until all pus has disappeared and culture of the expressed secretion is sterile.

Grant stated that he does not attempt to say definitely how mercurochrome injected into the prostate gland acts. It is his belief "that in this type of injection the mercurochrome acts with definite germicidal properties, and since it does remain in the gland and vesicles for an extended period (prostatic secretion often tinged for as late as four weeks) it prevents further bacterial growth. It does not seem likely that it acts in some obscure biological way as it does when injected intravenously. Indeed, the entire basis of our hypothesis is the introduction of some antiseptic directly into the seat of inflammation in an endeavor to check that process by direct action."

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38. Grant, Owsley: The Treatment of Chronic Prostatitis by Injection, J. Urol. **33**:631-638 (June) 1935.

McCarthy [39] recommended direct intraprostatic injection of from 3 to 8 cc. of medium into each lateral lobe through the panendoscope. The injection is made into the median lobe one week later. In his patients so treated the number of injections varied from three to seventeen.

Cano,[40] of San Salvador, introduced perineal intraprostatic injection (along with Townsend and Valentine) in 1917. Von Lackum later suggested injection through the anterior wall of the rectum. McCarthy has given injections to 40 patients, of whom all but 2 reported definite improvement. In 16 all symptoms disappeared, and they were discharged as clinically cured.

Townsend [41] stated that in noncooperative patients he has accidentally injected fluids into the prostatic sheath, into the submucous group of glands and even through the membranous urethra into the bladder. The only aftermath was temporary retention of urine due to elevation and blocking of the neck of the bladder and to an increased volume of these submucous groups of glands. Townsend, immediately prior to enucleation, injected alum carmine, methylene blue and india ink into obstructing adenomatous prostate glands. All dyes except the india ink disappeared during the hardening and staining of the specimens. India ink, however, was found distributed irregularly in the prostatic tissue, some pigmented granules within the lumens of the glands as well as in the epithelium, some within blood vessels, involving all the coats, and the remainder diffusely scattered. The body of a criminal, aged 22, was chosen for intraprostatic injection five minutes after his electrocution; 15 cc. of a 20 per cent suspension of india ink in a saline solution was injected into each lateral lobe, and immediately the tissue was removed for section. Under microscopic section the black pigment was diffused in all muscular, glandular and vascular tissue. The epithelial lining of the tubules and alveoli were all more or less extensively stained, partly diffusely and partly in the form of dark pigment granules. Many of the lumens of the glandular structures contained the pigment, as did the walls of the blood vessels and their endothelium. All operators advise placement of injected substances in depots in the gland. Townsend concluded that perineal puncture is the shortest surgical route for attack on the prostate infections, that substances injected into the prostate diffuse throughout the

39. McCarthy, J. F.: Recent Advances in Instrumental Urology, J. Urol. **33**: 303-309 (March) 1935.

40. Cano, F. G.; Townsend, T. M., and Valentine, J. J.: The Intravenous and Intraprostatic Injections of Methyl-Phenol and Normal Phenol Serum in Gonorrhea, M. Rec. **91**:715-719 (April 28) 1917.

41. Townsend, T. M.: Intraprostatic Injections, J. Urol. **35**:75-79 (Jan.) 1936.

gland and that since substances so injected find their way into prostatic blood vessels, no medicament should be introduced into the gland which will not be tolerated by the general circulation.

Toxic Hyperplasia.—Barnes [42] reported on experiments on animals which were performed to determine if sterile secretion from the prostate gland was toxic and, if so, its effect on animals in comparison with other substances of known toxicity. Mice were given intraperitoneal injections of varying amounts of secretion from this gland. Most of that used contained less than 5 pus cells per high dry field and was obtained by massage of the gland under aseptic conditions; it was proved sterile by cultures before injection. Other specimens were obtained in the ordinary manner without the use of aseptic technic. It was found that there was no difference in the toxic effect between the sterile and the unsterile secretion from the prostate gland, whether originally sterile and containing pus or whether contaminated after being obtained. This is not unusual when the natural immunity of mice and rats to organisms which are pathogenic to human beings is considered.

Secretion from the prostate gland which contained no pus was toxic when injected into mice, rats and other animals, the toxicity of 1 cc. being comparable to that of ¼ grain (0.016 Gm.) of morphine. It is the belief of Barnes that an excessive amount of secretion retained in the prostate gland results in absorption of this toxic substance, with resulting general and local toxic symptoms. The term toxic hyperplasia of the prostate gland is used to designate this condition.

Massage or Resection.—Emmett [43] reviewed the borderline type of case in which the question arises as to whether urinary symptoms of obstruction are caused by true prostatic hypertrophy or merely by prostatitis or chronic, granular, cicatricial prostatic urethritis. Clearcut cases of any kind are readily recognized by the experienced urologist. Unfortunately, however, all patients do not present signs which make for a definite and unequivocal diagnosis. This group includes the cases in which there are indefinite bars, contractures of the neck of the bladder, slight lobar hypertrophy or chronic cicatricial urethritis. Clinical symptoms are often misleading and of little help. A number of cases of this type have been encountered, and the author adopts the attitude of "when in doubt, give conservative treatment a trial first." This consists of: vigorous prostatic massage, after which the bladder is lavaged with a solution of potassium permanganate (1:8,000). Two or three treatments are given each week for a period of from two weeks to a month

42. Barnes, R. W.: Toxic Hyperplasia of the Prostate Gland, J. Urol. **35**:70-74 (Jan.) 1936.

43. Emmett, J. L.: Prostatic Massage or Resection? Minnesota Med. **19**:160-165 (March) 1936.

or more. If the prostatic urethra is very cicatricial, the urethra is dilated once or twice. If associated chronic pyelonephritis is present, it is also treated. If the symptoms of urinary obstruction do not improve and if the amount of residual urine does not definitely decrease during this interval of treatment, the inflammatory element is considered of secondary importance to the obstructive factor, and transurethral resection of the neck of the bladder is then performed. The amount of tissue removed under such circumstances is usually small and ranges from 1 to 3 Gm.

After such a procedure the patient almost always empties his bladder completely, and the symptoms are controlled adequately. After a month or six weeks, prostatic massage may be instituted again if any symptoms persist, but this is not usually necessary.

Emmett reported in detail twelve such borderline cases coming under his observation in 1934 in which a preliminary course of conservative treatment failed to give adequate relief, and transurethral resection was necessary. Recently, all 12 patients responded to questionnaires and 8 were completely satisfied with the results. Two patients still complained, some of nocturia, and 2 still had some symptoms of urinary obstruction. Emmett has found the Braasch-Bumpus instrument satisfactory for resecting the neck of the bladder in such cases.

Stone.—Walters and Thiessen [44] reported 4 cases in which perineal prostatectomy was performed for stone. They concluded that the surgical treatment for prostatic calculus is indicated: first, when the stone is large enough to obstruct the flow of urine; second, when by its size and position it prevents removal by transurethral methods, and, third, when removal of the calculus will allow more adequate treatment of the prostatic and urinary infection. It is obvious from the study of these cases that surgical operation is only a stage in the treatment and that postoperative care is essential to produce amelioration of symptoms or cure.

Carcinoma.—Barringer [45] stated that examination of small carcinomas of the prostate gland found at necropsy, clinically undiagnosed and undiagnosable, indicated that in about 75 per cent of all cases the posterior lobe of the gland is the site of origin of the growth. When the carcinoma has become sufficiently large to be diagnosed clinically, in most cases it has extended beyond the posterior lobe into the lateral or median lobes and into the sheath of the prostate.

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44. Walters, Waltman, and Thiessen, N. W.: Perineal Prostatectomy for Stone: Report of Four Cases, Minnesota Med. **19**:177-179 (March) 1936.

45. Barringer, B. S.: The Treatment of Prostatic Carcinoma, Surg., Gynec. & Obst. **62**:410-412 (Feb. 15) 1936.

The control of carcinoma of the prostate gland depends on diagnosis in its early stage. Biopsy of tissue secured through the perineum by aspiration has been a valuable aid in determining the severity of the lesion. Tissue from the gland is obtained in about 80 per cent of the cases in which aspiration is carried out, and its pathologic diagnosis depends on special training on the part of the pathologist. The normal prostate gland is shaped like a somewhat flattened cone with its base at the end of the bladder and its apex downward along the urethra. The entire gland is below the bladder. The posterior lobe, because of its location ½ inch (1.27 cm.) below the neck of the bladder, is difficult to irradiate properly by the implantation of radon seeds through the bladder opened suprapubically.

Progress in the operative control of carcinoma of the prostate gland has been slow. The field of operation is small, and surgical removal presupposes much trauma of the carcinomatous tissue. The combination of high voltage roentgen therapy and intraprostatic irradiation affords the only means to control the lesion in these difficult cases. These two methods of treatment should be carried out simultaneously as far as possible. The treatment of retention is by means of transurethral or suprapubic partial prostatectomy with the high frequency loop. This operation is followed by irradiation in accordance with the technic outlined. Modifications of the operation and the dosage of irradiation must depend on the conditions found in the patient treated. A study of 351 consecutive cases of carcinoma of the prostate illustrates what even inadequate irradiation of the gland alone can accomplish. In more than half of the cases in which the disease was controlled were the lesions classified as extensive; that is, the growth had extended beyond the prostatic sheath and involved the base of the bladder or the perivesical lymph nodes. The majority of patients who die usually succumb within the first two years. Twenty-nine (8.3 per cent) were well for three years and 20 (5.7 per cent) for five years. If the carcinoma is considered as controlled, the patient must reveal no signs of carcinoma in the prostate by palpation, by cystoscopy or by biopsy of tissue secured by aspiration. This is also true of the skeletal and other parts of the body which might be affected by the carcinoma. The fact that the roentgenogram revealed metastasis in 156 cases and that in 44 of these (28 per cent) there was metastasis to bone indicated how serious is the problem of control.

Jacobs [46] stated that within the three years since he has adopted the method of transurethral resection he has performed this operation on 15 of 19 patients who definitely had a malignant growth of the gland.

46. Jacobs, Arthur: Transurethral Resection of the Malignant Prostate with a Review of Fifteen Cases, Brit. J. Urol. **7**:321-329 (Dec.) 1935.

The McCarthy resectoscope was used in all the cases, and the technic was identical with that employed in cases of benign hypertrophy. Preoperative drainage, either by the indwelling urethral catheter or by the suprapubic route, is the rule, the choice of method depending principally on the degree of renal impairment. Bleeding that results from resection of the malignant prostate gland is usually less than that encountered after the resection of the benign type.

Of the 14 patients who survived operation, 12 were successfully relieved of obstructive symptoms. Of the other 2, 1 required the insertion of a suprapubic tube in spite of the resection, and the other had suprapubic leakage from a previous cystostomy wound even after resection had been performed twice. Jacobs compared the duration of life of these patients with that of 4 other patients with carcinoma of the prostate gland who were treated by different methods within this same period. Three of these underwent suprapubic cystostomy only; 1 lived seventeen months, another five months and the third fifteen days. The fourth patient, who did not have marked obstruction, was treated by means of radium inserted into the prostate gland through a perineal exposure; he survived for one year.

Player [47] stated that cases of carcinoma of the prostate gland may be divided into two groups, according to the physical findings. In group 1 are the cases of carcinoma in the early stage within the capsule of the prostate, with areas of marked induration and fixation of the gland. In group 2 are the cases in which the growth is in the late stage, with infiltration of the contiguous structures, with or without metastasis and urinary symptoms. In group 1 the stony hardness and fixation can be palpated rectally, and evidence of the fixed gland may be seen on cysto-urethroscopic examination. When there is infiltration of the prostate and the adjoining structures, little, if any, dilatation is observed when the posterior portion of the urethra is filled with water. Radical surgical operation is the method of choice for treatment in group 1, as it offers the only opportunity of permanent cure. Roentgen therapy should precede operation in order to block the radiosensitive cells of the diseased prostate and the nodes into which the lymphatics of the prostate drain.

In group 2, or in cases in which there are no urinary symptoms and in which the roentgen picture is normal, in which there is infiltration of the immediate contiguous structures, the treatment should be the same as that in group 1, with the addition of radium implants, seeds or needles; these are inserted into the infiltrated areas in which excision is contraindicated or impossible. In cases in which metastasis and

47. Player, L. P.: Carcinoma of the Prostate: Treatment, California & West. Med. **44**:299-300 (April) 1936.

urinary obstruction have occurred, treatment may be by the following methods: partial perineal prostatectomy, with implantation of radium into the remaining portion of the gland; perineal exposure of the prostate, with the implantation of radium under direct vision into the gland and invaded contiguous structures; suprapubic exposures of the prostate through a cystotomy opening and partial removal of the gland and implantation of radium according to the Ferguson technic; transurethral resection of the obstruction, combined with suprapubic cystotomy and implantation of radium; transurethral resection of the obstruction and high voltage irradiation. The deciding factor in the selection of any method for treatment in the cases in group 2 is usually the condition of the patient, and some patients may even need implantation of the ureters into the bowel, or to the skin when infiltration has extended into the bladder.

Hale [48] stated that symptoms of carcinoma of the prostate gland are as obscure as those of carcinoma in general. Frequency of urination is the most common symptom. When there is no associated hypertrophy of the gland and the bladder seems to be completely emptied, there often are noted irritation of the deep portion of the urethra and pain in the penis during micturition. Pain, usually the dull aching or rheumatic type referable to the sacro-iliac region, penis, perineum, thighs, inguinal region or suprapubic region, is often an early symptom. Gradual diminution of strength and loss of weight, associated with the other threads of evidence pointing to carcinoma of the gland, are significant but do not occur early.

Early symptoms of carcinoma of the prostate gland may be summarized as follows: Those associated with hypertrophy are frequency of urination, difficulty in urination, urgency and pain in the penis during urination. Those associated with benign hypertrophy of the gland are increased difficulty in urination, less urgency and occasional retention of urine. Patients with carcinoma with chronic prostatitis manifest frequency of urination and irritation of the deep portion of the urethra.

Scholl [49] stated that pathologically and clinically there are two types of carcinoma of the prostate gland. The first is the more common type, and its degree of malignancy is lower than that of the second type. The structure is made up of cells and glands and retains the normal or glandular structure. The cells are partly differentiated and fairly regular in size and shape and retain the long, tufted end projecting into the glandular lumen, which is the most significant feature of

48. Hale, N. G.: Carcinoma of the Prostate: Early Symptoms and Diagnosis, California & West. Med. **44**:298-299 (April) 1936.

49. Scholl, A. J.: Carcinoma of the Prostate: Pathology and Prognosis, California & West. Med. **44**:298 (April) 1936.

epithelium of the prostate gland. Clinically, these prostates are large, nodular and stony and produce the symptoms of obstruction that first call attention to their presence.

The second type of carcinoma is often confused with lymphocytic infiltration. The malignant cells that have migrated into the stroma often show a streaked or etched-out appearance, in contrast to the clumped, localized disposition of lymphocytic infiltration. Clinically, the glands of this type are small, fibrous and firmly fixed. They are extremely malignant, metastasize readily and are often unrecognized, since paralysis may occur as a result of metastasis before the glands have reached sufficient size to produce symptoms of the urinary tract. Their small size often leads to the erroneous conclusion that the patients are satisfactory surgical risks and to operations, but the results are unfavorable.

Young's [50] statistics reveal that a fifth of the patients who come for relief of obstruction of the prostate gland have carcinoma, that the growth is usually in the form of a nodule or area beneath the posterior capsule in the posterior lobe and that in this position it is readily palpable by rectum and should be recognized by its marked induration. The perineum is the only route by which the diagnosis can be confirmed, and if the disease is not too extensive, a radical cure can be obtained. Cure resulted in more than 70 per cent of the cases in which the prognosis was at all favorable. Carcinoma of the prostate gland is usually unrecognized for a long time. Every physical examination should include this gland. If marked induration is present, it should cause suspicion of carcinoma. In such cases, perineal operation to expose the prostate and confirm the diagnosis should be done. If the importance of these facts would be realized, many times operation for carcinoma of the prostate gland could be performed sufficiently early for a radical cure.

Osteitis Pubis.—Lazarus [51] stated that osteitis pubis is a rare complication following surgical procedures on the bladder through a suprapubic incision. The significant symptoms of this complication are pain over the lower attachments of the rectus abdominis muscles, the body, symphysis and rami of the pubic bone and the inner aspects of the thighs with spasm of the abductor muscles, so that the patient finds it painful to walk, to spread the thighs and to cough. A late symptom is pain on defecation and terminal dysuria. Fever is rarely present throughout the disease but may exist during the early stages. Symptoms usually occur in about from two to three weeks after operation.

50. Young, H. H.: Recent Work on the Prevalence of Carcinoma of the Prostate, Tr. Am. A. Genito-Urin. Surgeons **28**:317-329, 1935.

51. Lazarus, J. A.: Osteitis Pubis Following Suprapubic Prostatectomy, Ann. Surg. **103**:310-315 (Feb.) 1936.

The process rarely progresses to suppuration and the formation of a fistula. The treatment is palliative except in the few cases in which suppuration occurs. In most of the cases the condition responds to baking and massage and to the application of a properly fitted plaster cast. The disease is self-limited, with symptoms lasting from two to six months, followed by resolution and complete recovery.

URETHRA

Stone.—Traczyk [52] described the various types of urethral calculi and the symptoms they produce on the basis of 6 illustrative cases. As a rule such calculi are solitary, the stone being a fragment of one originating in the pelvis of the kidney or a bit of débris remaining from lithotrity. They are exceptional in females, owing to the shortness of the urethral canal, but in males they may be found alike in children and adults. The chemical state of the urine plays an important part in their formation, the lithiasis being acid, alkaline or neutral, expressing itself in the formation of urates, oxalates and phosphates. The condition of the urethra above the stone is never normal. Since the lesions are mechanically produced, the canal behind the stone dilates into a voluminous pocket. On this retrostrictural dilatation constant trauma is inflicted, associated with stagnation of urine and irritation from toxic products, which may result in diverticulosis or even in ulceration. The symptoms vary from case to case; the site of the stone is responsible for this, the tolerance of the urethra varying with the situation. Stones in the prostatic urethra cause the most pain, which is felt in the rectal, perineal or sacral regions. Incontinence is more striking if stones are at this site also. Micturition is impeded, and dribbling takes place. Diverticular calculi may remain a long time without giving any indication of their presence.

Treatment varies with the individual case, depending on the size and site of the stone and on the condition of the urethral canal. If the stone is small and only recently engaged in the anterior part of the urethra and the latter is not contracted, an attempt may be made to propel it forward by pressure exerted from behind the calculus. Occasionally it may be sufficient to ask the patient to urinate while the meatus is held closed, the jet dilating the canal enough to force the stone out. Injections of oil or cocainization of the canal combined with these maneuvers may occasionally relieve the spasm. If the stone is close to the meatus it may be liberated instrumentally by a curet or small forceps, but lithotrity or blind extraction should never be resorted to. Removal of the stone under urethroscopic control is the only pro-

52. Traczyk, Sigismond: Les calculs de l'urétre, J. d'urol. **41**:224-235 (March) 1936.

cedure permitting the requisite precision of action. By this means the stone can be grasped and withdrawn at the same time as the tube.

When the calculus cannot be removed in this way, recourse must be had to external urethrotomy with suture, provided there is no marked inflammation. If the stone has been arrested by a stricture, a filiform bougie left in situ from twenty-four to forty-eight hours may sometimes dilate the urethra enough to allow the stone to pass out. If this fails, internal urethrotomy is indicated, but only if the stone is movable, of small size and not associated with pronounced inflammatory lesions.

If the stone is in the prostatic urethra, an attempt should be made to push it back into the bladder with a sound. This can sometimes be done if the stone is recent. Then, if the canal is sufficiently dilated, it will be expelled easily; otherwise it can be crushed in the bladder. If it is impossible to push it into the bladder, its extraction under urethroscopic control should be tried again. If endo-urethral maneuvers fail or if the stone is large, a hypogastric incision is indicated; if the prostate proves to be an obstacle, prostatectomy can be done later.

Recurrence of urethral calculi has been reported a number of times. Such recurrence is caused almost always by strictures that have been poorly cared for, or by parts of the calculus that were left in the urethra. For these reasons it is preferable to carry out external urethrotomy, which makes it possible at the same time to section the stricture and to extract all the calculous formations within the urethra.

Diverticulum.—Kretschmer [53] reported a case of diverticulum of the urethra in a child 6 months of age. This lesion may occur in either males or females. In males it may be located in the anterior or in the posterior part of the urethra. In general, diverticulum of the urethra is rare, especially in children. A survey of the literature revealed reports of only 20 cases in which the diverticulum was in the anterior part of the urethra in male children.

Congenital diverticulum of the anterior part of the urethra occurs on the ventral wall of the urethra. The diverticulum is often found immediately behind the fossa navicularis and opens with a narrower or wider mouth into the urethra. The pouches vary in size from 1.5 cm. to 4 cm. by 3 cm. or 2 cm. A diverticulum of the urethra may be congenital or acquired. The congenital diverticulum is seen in the anterior part of the urethra, and in a large percentage of cases it occurs in young persons. The acquired diverticulum occurs mainly in the posterior part of the urethra, and the causes, such as urethral calculus, stricture, perforation of the urethra resulting from injuries and rupture of cysts, do not as a rule occur in childhood. The urethral diver-

53. Kretschmer, H. L.: Diverticula in the Anterior Urethra in Male Children, Surg., Gynec. & Obst. **62**:634-640 (March) 1936.

ticulum not infrequently becomes the site of an inflammatory process caused by the stagnation of the urine within it and by superimposed infection. This may lead to a fistulous opening on the surface of the penis. Calculus formation may occur in a diverticulum. The obstruction to the flow of urine caused by the pressure of the filled sac on the urethral lumen leads to dilatation, infection and destruction of the upper part of the urinary tract. In some cases the diverticulum was emptied completely by pressure, only to fill again later. Although complete retention of urine is rare, this symptom was the direct cause of the patient's admission to the hospital in Kretschmer's case. The retention is mechanical in origin. The presence of the large diverticulum caused pressure on the urethra; hence complete retention followed.

The prognosis in these cases is dependent on the extent of the pathologic changes which the diverticulum has caused in the upper part of the urinary tract through obstruction and ensuing infection; this means early diagnosis and early operative intervention before the onset of irreparable injury to the upper part of the tract. When the patient is operated on before urinary stasis has caused serious harm to the upper part of the urinary tract, the prognosis is good. This is seldom the case when the operation occurs after the urinary tract has been injured. Excision of the diverticulum is the preferable treatment in this group of cases. It can be performed with relative ease and simplicity. Invagination of a small diverticulum may be tried, but as the majority of patients have large sacs, invagination is not feasible.

Stricture.—Rusche and Bacon [54] stated that stricture of the urethra which is neglected is the significant causative factor of extravasation of urine in the majority of cases. Urinary extravasation requires immediate radical operation; no palliative measures are justifiable. There are three main courses of action: diversion of the urinary stream; multiple incisions of all infiltrated areas, and, at intervals, gradual dilation of the urethra. Treatment of the stricture should be carried out later, when a process of slow dilation will produce a more satisfactory result. Suprapubic cystostomy is a satisfactory method of diverting the urinary stream. Perineal cystostomy is not desirable, as any procedure directed toward cutting the stricture at the time of the extravasation, in the opinion of Rusche and Bacon, is unwarranted.

Carcinoma.—Lazarus and Schneider [55] stated that primary carcinoma of the female urethra is of relatively rare occurrence; only 150 cases

54. Rusche, C. F., and Bacon, S. K.: Urinary Extravasation Following Urethral Stricture, California & West. Med. **44**:284-287 (April) 1936.

55. Lazarus, J. A., and Schneider, A. D.: Primary Carcinoma of the Female Urethra Treated by Complete Extirpation of Urethra, J. Urol. **35**:235-240 (Feb.) 1936.

are on record, including the case presented by them. Chronic irritation appears to be an insignificant predisposing factor. Bleeding from the urethra, difficulty in voiding and a tumor at or near the meatus constitute the outstanding symptoms of the disease. Since the majority of the patients are seen late in the development of the tumor, about a third of them present evidence of lymphatic involvement at the time of the first examination. Although several types of treatment have been advocated for this condition, it is most satisfactorily managed by complete excision of the growth, including the inguinal lymph nodes when involved, followed by thorough irradiation of the inguinal regions and site of the tumor.

Hypospadias.—Cabot [56] stated that there are certain basic requirements for a completely satisfactory operation for the cure of hypospadias. Such a procedure should completely overcome the disability; it should avoid the production of new disabilities, such as the formation of stricture at various levels or the later growth of hair within the newly formed urethra as the result of the utilization of inappropriate skin flaps; it should be sufficiently simple and certain of freedom from postoperative complications so that it can be performed with reasonable possibility of success by a well trained surgeon. At present there are in use three principles represented by three types of operation for this condition which, in their historical order of presentation, are the Thiersch and Duplay, the Bucknall and the Ombrédanne operation. The Thiersch-Duplay type of operation has been followed by some exceedingly favorable results, but is attended by many technical difficulties and is frequently complicated by the formation of a fistula. The two disadvantages of the Bucknall operation, as stated by Bucknall in his original report, were that it could not be applied to patients who have perineal hypospadias and a cleft scrotum and that it utilized skin from a hair-bearing area, which might later cause complications. The Ombrédanne operation is complicated and requires multiple stages in order to achieve a satisfactory result. Objections to it are that there is danger of formation of stricture at the junction of the posterior with the anterior portion of the plastic formation of the urethra, and, as in the Bucknall procedure, it utilizes hair-bearing areas of skin.

Cabot presented a procedure which is a modification of the Bucknall operation, by which the hair-bearing areas are avoided in the formation of the inner tube of the urethra. The skin for the formation of the inner tube of the urethra is taken from the skin of the shaft of the penis, which does not bear hair, just as in the operation of Thiersch and Duplay. The remainder of the procedure follows the technic of

56. Cabot, Hugh: An Improved Operation for Hypospadias, Proc. Staff Meet. Mayo Clin. **10**:796-798 (Dec. 11) 1935.

Bucknall, in that the lateral flaps from the shaft of the penis and from the scrotum are dissected up, the penis is turned down and these flaps are united over a broad surface by the use of a quilled mattress suture. Cabot's results have shown the same freedom from formation of fistula and the same possibility of carrying out the whole procedure. it being assumed that the deformity of curvature has previously been satisfactorily corrected in two stages rather than in multiple stages, as in the original Bucknall operation. The position and caliber of the meatus can be satisfactorily planned, and freedom from a funnel-shaped opening, as well as avoidance of stricture, can be obtained with certainty.

Congenital Obstruction.—Stevens,[57] in an analysis of the results of 3,600 urologic examinations of women, stated that congenital strictures of the female urethra are common. Diaphragms or valves, in addition to several other congenital anomalies responsible for symptoms of obstruction, are occasionally found in the female urethra. The olive tip bougie, the skeneoscope and the urethroscope are the most useful instruments in the detection of urethral obstructions and should always be employed in the examination of infants and children as well as in that of adults who have symptoms suggestive of a pathologic condition of the urinary tract. Meatotomy is the procedure of choice in the treatment of this condition.

Lymphoma.—Gray[58] described the cases of 11 women with a urethral disease which was characterized by chronic urethritis with or without ulceration, which remained extremely chronic or indolent or progressed to urethral stricture or to extensive urethral ulceration. The ulceration may extend beneath the clitoris and the labia or about the introitus and to the sides of the rectum. A positive Frei reaction in 9 of these 11 patients indicated that this syndrome is caused by the virus of lymphogranuloma venereum, poorly termed lymphogranuloma inguinale.

This condition is also characterized by failure to respond to any treatment. In the cases reported antisyphilitic therapy and antimony and potassium tartrate have no apparent effect. High frequency fulguration (in 2 cases), roentgen irradiation (in 1 case) and inoculation with malaria (in 1 case) did not modify the progress of the disease. It would seem that cure of lympogranuloma venereum results only when the patient becomes immune to the virus, as with other virus diseases. The transfer of passive immunity by injection of serum from persons with healed lesions seems to offer the greatest possibilities of cure, although few studies of this method have been made.

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57. Stevens, W. E.: Congenital Obstructions of the Female Urethra, J. A. M. A. **106**:89-92 (Jan. 11) 1936.

58. Gray, L. A.: Lymphopathia Venereum—"Lymphogranuloma Inguinale"—of the Female Urethra, Surg., Gynec. & Obst. **62**:745-752 (April) 1936.

TESTIS

Tumors.—Desjardins, Counseller and Gianturco [59] stated that 155 patients with tumor of the testes had been seen at the Mayo Clinic from 1920 to 1929. An analysis of these cases reveals that the majority of the neoplasms of this organ develop between the third and the sixth decade of life. In all but 2 cases the tumor was unilateral. The relation of testicular growth to undescended testis and to the influence of trauma could not be ascertained. The results of treatment were considered from the standpoint of orchidectomy alone, roentgen therapy alone and combined orchidectomy and roentgen therapy. Surgical intervention, combined with or followed by roentgen treatment, gave the most satisfactory results. This may be misleading, because none of the patients in this preferred group presented evidence of tumor for more than one year, and all were apparently free from metastasis. The patients treated by simple orchidectomy also constituted a preferred group. In the group of patients treated with roentgen rays only, the 16 patients who had died had an average survival period of eleven and four-tenths months, a period longer than that for corresponding patients in the two other groups. The impression is that patients receiving the combined forms of treatment derived more benefit than those treated by surgical methods only, or by roentgen therapy only, but in order to determine the relative value of each method by itself in comparable cases a more thorough test should be made. On the whole, roentgen treatment alone seems preferable for embryonal carcinoma, whereas for the mixed or teratoid tumor, surgical removal combined with thorough postoperative irradiation seems indicated.

Undescended Testes.—Spence and Scowen [60] reported that it has been shown that the injection of extracts of the anterior lobe of the pituitary gland into immature animals produced an increase in growth of all the tissues of the testis, and, as a result of stimulation of the interstitial tissue, enlargement of the penis and accessory genital glands. Spermatogenesis was not produced in immature mammals by means of these extracts. Similar results were obtained with extracts of the urine of pregnant women, the gonadotropic principle of which is probably derived from the placenta. It has also been shown that the injection of extracts of the anterior lobe of the hypophysis or of the urine of pregnant women causes descent of the testis in immature monkeys, in which animals they are situated in the inguinal canal.

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59. Desjardins, A. U.; Counseller, V. S., and Gianturco, Cesare: Results of Treatment in Tumors of the Testis, Am. J. Surg. **27**:71-78 (Jan.) 1935.

60. Spence, A. W., and Scowen, E. F.: The Use of Gonadotropic Hormones in the Treatment of Undescended Testes: Preliminary Report, Proc. Roy. Soc. Med. **28**:427-435 (Feb.) 1935.

Eleven patients with undescended testes between the ages of 4½ and 15 years were treated with gonadotropic substance extracted from the urine of pregnant women. The dose used in most cases was 500 rat units injected intramuscularly twice weekly. Five of the patients had bilaterally undescended testes: During treatment both testes descended into the scrotum in 2 cases, one descended in each of 2 cases, and the position of the testes was unchanged in the remaining case. The remaining 6 patients had one undescended testis; in 3 of these the testis descended into the scrotum. Thus, 9 of 16 undescended testes entered the scrotum during treatment. The time taken to effect this change varied from two to eleven weeks. The testes which had not yet responded received treatment for from three to nine weeks. The mechanism whereby the descent is brought about is unknown. In view of the rather unsatisfactory surgical results, the authors expressed the belief that in the treatment of undescended testis a trial should be made of this form of therapy before surgical measures are considered.

Testicular Prosthesis.—Barney [61] reported a case in which a testicular prosthesis was used, together with a review of similar cases presented in the literature. The various substances used for implantation included marble, glass, plaster, plaited silk, paraffin, petrolatum, vulcanite, ivory, india rubber, celluloid and silver. Paraffin, celluloid and silver seemed to be the most frequently used. The other materials mentioned seemed to have the disadvantages of weight, disintegration or infiltration by lime salts. According to Cartier, the prosthetic ball should not weigh less than 12 grains (0.87 Gm.), for if it is lighter it is likely to be drawn toward or even into the inguinal canal by muscular contraction. From his knowledge of the nonirritating qualities of silver, Barney expressed the opinion that this is the best material to use. It also has the advantage of being made into any size, shape or weight.

A testicular prosthesis has been employed for various reasons. In the days when bilateral castration was performed for the relief of prostatic obstruction, there was a demand for restoration to cosmetic perfection. In several cases the method was used after orchidectomy for tuberculosis, tumor or gonococcic or other infection. Others desired an artificial testis to fill the empty scrotum produced by cryptorchidism. In many patients there was a definite, sometimes profound, mental derangement occasioned by the half or completely empty scrotum. In all the patients it was noted that not only improvement but complete

61. Barney, J. D.: A Consideration of Testicular Prosthesis. Tr. Am. A Genito-Urin. Surgeons **28**:369-373. 1935.

restoration of the normal mental status resulted a short time after operation. In his case Barney used a hollow silver ball, 7/8 inch (2.2 cm.) in diameter, with thin walls.

SPERMATIC CORD

Tumors.—Thompson [62] reviewed the literature on tumor of the spermatic cord, epididymis and testicular tunics and reported 41 cases observed at the Mayo Clinic before Jan. 1, 1935. The tumors included 26 of the spermatic cord, 13 of the epididymis and 2 of the tunica vaginalis.

A tumor of the spermatic cord sometimes attains enormous size. The largest ones are composed of lipomatous tissue in their entirety or are mixed with other tissues, forming a myxolipoma or myxofibrolipoma. As a general rule, growth of such a fatty tumor is extremely slow. In the majority of cases the growth springs from the subserous fat around the margin of the internal inguinal ring and in enlarging grows along the inguinal canal, distending it and thus acting as a predisposing cause of hernia. When the growth is small, it is easy to distinguish at operation between the true lipoma of the spermatic cord and the more common lipoma of the properitoneal fat. If, however, the tumor is large, it is often impossible to say that its origin is not from the spermatic cord. A lipoma of the spermatic cord always should be surrounded by the tunica vaginalis communis and should derive its main blood supply from the vessels of the cord, but in time the true lipoma of the cord often will break through the tunica vaginalis communis and will connect so closely with the properitoneal fat that it appears to be of that origin. In this series of cases there were 21 cases of lipoma, in 14 of which the growth was associated with inguinal hernia. In all cases, nevertheless, the growth apparently arose from the spermatic cord, and many questionable cases were excluded. Since more than 7,000 operations for inguinal hernia were performed at the Mayo Clinic in the period covered by this review, it can be seen that the incidence is not high. Other benign tumors of the spermatic cord include fibroma, myxoma, myoma, lymphangioma, dermoid cyst and cystic tumor arising in cell rests of the wolffian body. The most common malignant tumor of the spermatic cord is the sarcoma or some combination of sarcomatous tissue with other tissue, producing a tumor which is termed myxosarcoma, liposarcoma, chondrosarcoma, fibrosarcoma or rhabdomyosarcoma.

Tumors of the epididymis occur in the proportion of 40 per cent benign and 60 per cent malignant. The fact that approximately 40

62. Thompson, G. J.: Tumors of the Spermatic Cord, Epididymis, and Testicular Tunics, Surg., Gynec. & Obst. **62**:712-728 (April) 1936.

per cent are benign should be kept in mind, for there is the possibility of a favorable prognosis after surgical exploration; this should justify the surgeon in urging operation in all cases unless metastasis to other parts of the body can be demonstrated. Of the benign tumors of the epididymis, myoma and angioma are most common. Eight cases of each type have been reported in the literature in a total of 25 cases of benign tumor. One of the cases presented by Thompson is an instance of dermoid cyst, a hitherto unreported type of epididymal enlargement. Of 36 malignant tumors of the epididymis, 23 were of epithelial origin, 12 were of the sarcoma type and 1 a teratoma.

Of the tumors of the testicular tunics, those arising in the tunica vaginalis are far more common than those springing from the tunica albuginea. It is often difficult, and sometimes practically impossible, to distinguish a tumor of the tunica vaginalis from one arising in adjacent structures. For this reason, varying opinions as to the frequency of occurrence of these tumors have been expressed. A careful review of the literature discloses an approximate total of 52 cases, in 35 of which the growth may be classed as benign and in 17 as malignant. Only 4 cases of tumor of the tunica albuginea have been reported, all the growths being fibromas.

Thompson concluded from his study that approximately 70 per cent of all tumors of the spermatic cord are benign; approximately 40 per cent of tumors of the epididymis are benign and approximately 60 per cent of tumors of the testicular tunics are benign. Therefore, the prognosis is more favorable in cases of tumor of one of these structures than in cases in which tumor originates in the testis, for tumors of the testis are, almost without exception, highly malignant.

URINARY CALCULI

Higgins [63] reported the experimental and clinical results which have been obtained by the use of the acid ash diet with a high vitamin A content in the treatment of urinary calculi. Stones which were too large to pass spontaneously from the kidney in 23 cases were completely dissolved by this method, as indicated by roentgenographic studies and by pyelography. Seventeen patients who passed calculi at frequent intervals have been free from symptoms for more than two years since using the diet high in vitamin A.

The acid ash diet with a high vitamin A content is prescribed in addition to other therapeutic measures, such as eradication of infection and elimination of stasis. Since this regimen has been used, the incidence of recurrent stone has been reduced from 16.4 to 4.7 per cent.

63. Higgins, C. C.: Experimental and Clinical Observations on Urinary Calculi, New England J. Med. **213**:1007-1010 (Nov. 21) 1935.

In a period of two and a half years there has been only 1 instance of recurrent formation of stone following operative removal of lithiasis from the upper part of the urinary tract.

In another series of cases the stones diminished in size, but insufficient time has elapsed to warrant their complete solution. In other cases no decrease in the size of the calculi has been observed although the patient has followed the diet for a period of from four to five months. It is impossible to determine whether a noticeable decrease in the size of stones will occur after the diet has been followed for longer periods. It is Higgins' belief that if the stone is not producing definite renal injury and pain is not disabling the patient, conservative treatment should be attempted. If, in addition to therapeutic measures which have been used previously, a carefully planned diet is prescribed to which vitamin A is added postoperatively, the recurrent formation of stones can be reduced to a minimum.

LYMPHATICS OF THE LOWER PART OF THE URINARY TRACT

MacKenzie and Wallace [64] described a method of preparing the lymph nodes of the posterior wall of the abdomen in rabbits, which maintained the anatomic relations of surrounding structures. A series of experiments as to the part played by the lymphatics in the absorption of dye from some of the pelvic organs and the relation of the upward drainage to the kidneys was carried out in rabbits. There was no absorption from the healthy mucosa of the bladder and no marked absorption after varied forms of trauma to the mucosa of the bladder unless an acute ulcerative condition was produced. Dye injected into the wall of the lower third of the ureter passed toward the lumbar glands to the main lymphatic chain. Dye injected into the trigon, around the orifices of the ureters and around the neck of the bladder, passed to the glands at the bifurcation of the aorta through the lymphatic vessels. Breaking the continuity of the main lymphatic pathway by stripping around the termination of the aorta did not lead to the opening of subsidiary periureteral lymphatic routes but caused lymphatic edema of the pelvic organs. Tying off the lower end of one ureter leading to hydronephrosis and the simultaneous injection of dye into the wall of the bladder around the lower end of the other ureter resulted in the absorption of dye into the aortic chain as before and suggested its passage into the venous circulation to the heart and then to the kidneys. Dye injected around the renal pelvis resulted in absorption to the lumbar lymphatic chain.

64. MacKenzie, D. W., and Wallace, A. B.: The Lymphatics of the Lower Urinary and Genital Tracts: An Experimental Study, with Special Reference to Renal Infections, J. Urol. **34**:516-535 (Dec.) 1935.

UROGRAPHY

Cumming and Chittenden [65] stated that many of the inaccuracies of both intravenous and retrograde urography are well known, and the correct balance is an individual problem. Advantage must be taken of both methods, and serial or multiple exposures at carefully chosen intervals should be used to obtain the maximal amount of information. There should be not only a mutual knowledge of an entire given clinical picture but joint study of diagnostic indications, especially those afforded by urographic investigations, by both the roentgenologist and the urologist before the final diagnosis is made. It is their belief that intravenous urography has a rôle in the investigation of the urinary tract, although it is probable that the ideal medium and technic are still to be determined definitely.

Baker and Lewis [66] reported on multiple urograms as an aid in urologic diagnosis. Usually an ordinary film of the entire urinary tract is taken prior to cystoscopy. During cystoscopy catheters are passed into the pelves of the kidneys, nonobstructing catheters being used whenever possible. The catheters are then connected by means of metal adapters to syringes containing a known amount of from 15 to 20 per cent skiodan. Under direct fluoroscopic control the pelves and calices are filled by gravity. When satisfactory visualization is complete the catheters are drawn down about 8 cm. from the ureteral orifices. The roentgen ray set-up is then arranged, the catheters are withdrawn and 1 cc. of opaque medium is slowly injected into the lower part of the ureters. The first film is taken as the catheters reach the bladder. Two or three other films are then made as rapidly as possible. The time of exposure varies from one half to three fourths of a second, and the time between exposures is from eight to ten seconds. A residual film is made about ten minutes later. In cases in which ptosis of the kidney is suspected, a vertical film is taken after the last serial exposure.

The fluoroscopic part of the examination gives information which aids in determining the fixity of the urinary passages, the type of peristalsis, the relation of extra-urinary shadows, the movements of the kidneys with respiration and the passage of the medium down the ureter. The catheters are placed as high as possible, their ideal position being in the pelves of the kidneys. With practice, the roentgenologist is able to estimate accurately by the size and density of the shadow the amount of opaque medium which flows into the pelvis and calices.

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65. Cumming, R. E., and Chittenden, G. E.: Intravenous and Retrograde Urography: A Comparative Study, J. A. M. A. **106**:602-606 (Feb. 22) 1936.

66. Baker, E. C., and Lewis, J. S., Jr.: Multiple Urograms: An Aid in Urological Diagnosis, Radiology **24**:177-182 (Feb.) 1935.

The entire urinary tract is included as a routine in the examination. When examination of the gastro-intestinal tract is made, more errors are caused by incomplete examination than by any other factor. Bilateral and complete examination of the urinary tract when proper methods are used is not in most instances dangerous or disturbing to the patient.

Swick [67] stated that, like other methods in medicine, excretion urography has its limitations. Despite the years of existence of cystoscopy and retrograde pyelography, these methods still have their defects. Excretion urography cannot supplant cystoscopy, retrograde pyelography and ureteral catheterization. However, excretion urography has simplified urologic diagnosis and has eliminated to a certain extent retrograde pyelography, particularly when viewed in conjunction with the history and the physical and laboratory observations. It is simpler and less taxing to subject a patient to an intravenous urographic examination first.

Excretion urography has been of considerable aid in the presence of obstructive lesions of congenital origin, or of lesions either obstructive or infectious superimposed on congenitally anomalous conditions, under which circumstances retrograde pyelography may be mechanically impossible or dangerous. In nonfunctioning hydronephrosis, the nonvisualization of a conducting system incidental to the functional-anatomic derangement of the parenchyma of the kidney is of assistance as a means of localization and of diagnosis when considered together with the other clinical data. Excretion urography is well adapted to cases in which there are obscure abdominal symptoms and conditions and in which one is adverse or hesitates to subject a patient to the retrograde route of investigation. Excretion urography and retrograde pyelography should supplement rather than vie with each other as to superiority.

Hartung and Wachowski,[68] having been misled by spurious shadows in the renal region which were caused by ammonium chloride tablets, studied the absorptive capacity of the thirty-three tablets commonly prescribed. Sodium bromide, ammonium chloride and sodium bisulfate all cast dense shadows, much more in fact than pills of ferrous carbonate; the pills of ferrous carbonate have been quoted often as causing a confusing shadow.

Baretz [69] stated that the capacity of the renal pelvis must not be exceeded in pyelographic injection and that aspiration of the pelvis

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67. Swick, Moses, in discussion on Cumming and Chittenden.[65]

68. Hartung, Adolph, and Wachowski, T. J.: Extraneous Shadows Complicating Urography, with Special Reference to Radiopaque Pills, J. A. M. A. **106**:596-598 (Feb. 22) 1936.

69. Baretz, L. H.: Rupture of the Kidney Following Pyelography, J. A. M. A. **106**:980-983 (March 21) 1936.

should be a routine procedure to determine its capacity. To perform pyelography on a kidney which is severely infected is dangerous. Whenever possible, in the presence of acute or subacute infection, the pelvis of the kidney should be visualized by the excretory route. If the retrograde method is necessary, extreme care must be used. If there is no apparent pain or discomfort after the injection of from 15 to 20 cc., the operator should cease and visualize the pyelogram before attempting to inject any more of the medium. Pain is a constant symptom of rupture of the kidney; this may be localized or general. Nausea, vomiting, fever, chills and elevation of the pulse rate are commonly observed. There may be a diminished output of urine with the appearance of a mass in the renal area. Rigidity and abdominal distention are later signs. Tenderness over the kidney is always present. All symptoms and signs will vary with the extent of the rupture. The diagnosis is easily made on examination of the pyelogram. The extravasation may be extensive or localized to a small area perinephrically. Operation is usually indicated when the urogram shows extensive extravasation. Baretz reported 3 cases of rupture of the kidney following the indiscreet use of pyelography.

URINARY INFECTION

Helmholz [70] reported the successful use of phenylglycolic (mandelic) acid in the treatment of a 3 year old child who had considerable infection and numerous pathologic changes in the urinary tract. Reference is made to the original work of Rosenheim [71] on this subject. After urologic investigation of Helmholz' patient, diagnoses of bilateral megalo-ureter and bilateral pyelitis, with right hydronephrosis and stenosis of the left ureteral orifice, were made. Escherichia coli was obtained on culture of the urine from both ureters. The value for blood urea was 28 mg. per hundred cubic centimeters.

Treatment with methenamine and ammonium chloride was unsuccessful; a short period on a ketogenic diet temporarily improved the infection in the urinary tract but failed to render the urine sterile. The patient also had a cyst of the brain, which was operated on. During her convalescence from this operation, treatment was instituted with phenylglycolic acid. She was given 1.25 Gm. of phenylglycolic acid neutralized with sodium bicarbonate and 0.5 Gm. of ammonium chloride four times a day. When this treatment was instituted urinalysis revealed pus, grade 3, and culture revealed innumerable colonies of Escherichia

70. Helmholz, H. F.: Successful Treatment by Means of Mandelic Acid of a Child with Urinary Stasis and Infection, Proc. Staff Meet., Mayo Clin. **11**:231-232 (April 8) 1936.

71. Rosenheim, M. L.: Mandelic Acid in the Treatment of Urinary Infections, Lancet **1**:1032-1037 (May 4) 1935.

coli. Treatment was continued for ten days. The p_H of the urine varied between 5 and 5.6, and the concentration of (phenylglycolic) acid in the twenty-four hour specimens of urine ranged from 0.25 to 0.43 per cent. On the eighth day of treatment the number of organisms of Esch. coli in the cultures of the urine was definitely reduced, and on the ninth and tenth days after the institution of treatment the cultures were sterile and the urine was crystal clear; no pus was found on microscopic examination. After discontinuation of the drugs on the eleventh day, the p_H of the urine rose to 6. Cultures of the urine made on three consecutive days after the treatment had been stopped were sterile. The patient was dismissed and will be operated on later for relief of the urinary obstruction.

URINARY CALCULI ASSOCIATED WITH DISEASE OF THE BONE

Goldstein and Abeshouse [72] reported 14 cases of urinary calculi in association with various diseases of bones and also reviewed the literature on this subject. In 4 of their cases the condition developed after amputation of the extremities; in 2, after osteomyelitis; in 3, after fracture of the long bones; in 1, after fracture of the pelvis; in 1, after tuberculosis of the hip joints; in 1, after arthritis deformans with associated osteitis deformans, and in 2, in association with scoliosis.

A definite etiologic relationship apparently exists between urinary lithiasis and various chronic diseases of bone; consequently, in all cases of urinary calculi information concerning a previous injury or disease of the bone should be sought and carefully considered from an etiologic standpoint. The development of urinary calculi during the course of chronic disease of the bones is uncommon though not rare. Infection of the urinary tract secondary to acute or chronic infection of the bones or joints, such as arthritis or osteomyelitis, may be a predisposing factor in the formation of urinary calculi. Urinary calculi may develop after an injury of the vertebrae or cord. The formation of urinary calculi in the presence of rickets, osteitis deformans, osteomalacia, osteitis fibrosa of von Recklinghausen, osteitis fibrosa cystica associated with hyperparathyroidism and other diseases of bone appears to be dependent on a disturbance of the calcium and phosphorus metabolism which upsets the colloid-crystalloid equilibrium of the urine, with subsequent precipitation and coalescence of the urinary constituents. Careful attention should be given to providing an adequate diet in the treatment and prevention of urinary calculi of all patients, especially those with chronic diseases of the bones. A diet deficient in vitamin A

72. Goldstein, A. E., and Abeshouse, B. S.: Urinary Calculi in Bone Diseases: Review of the Literature and Report of Cases, Arch. Surg. **31**:943-981 (Dec.) 1935.

and in inorganic calcium and phosphorus is an etiologic factor in the formation of urinary calculi in the experimental animal and is reputed to be an etiologic factor in the clinical and experimental production of several types of chronic disease of the bones.

ULCERATIVE COLITIS FOLLOWING CYSTOSCOPY

D'Abreu and Lysaght [73] presented 3 cases of uremic colitis following cystoscopy. In all of them the procedure seemed justified. There was no evidence at that time that the kidneys were not functioning normally; in all 3 the examination was followed by failure of renal function and by the development of a marked degree of uremia in which symptoms of colitis were present. In 1 case the palpation by rectum of polypoid masses with ulceration led to the erroneous diagnosis of neoplasm of the rectum. Apparently this polypoid condition accompanies ulcerative uremic colitis, as it was present in both cases in which the patient died.

Cystoscopy may be a dangerous procedure; it is generally agreed that it is contraindicated in most cases of nontraumatic nephritis. In 1 of these cases subacute nephritis was present. However, this diagnosis was not made before cystoscopy, owing to the unequivocal signs and symptoms present. Necropsy in the other fatal case failed to reveal any evidence of preexistent nephritis, and the uremia was ascribed to the use of the cystoscope. In the third case, acute uremia, from which the patient recovered, occurred after cystoscopy; this patient, according to clinical and biochemical examinations, did not have nephritis.

URINARY INFECTION AND CERVICITIS

Herrold, Ewert and Maryan [74] reported that in a series of 32 cases in which the patient had an irritable condition of the bladder, there was complete relief or marked improvement in two thirds of them after coagulation of the cervix. In coagulating the cervix the heavy mucoid discharge from the cervix was dissolved and removed with caroid powder, which dried the canal and made its surface more visible. No local anesthetic was used in the cervix. A tenaculum was not used to hold the cervix in place because adequate exposure was obtained with Guttman's operative speculum. Coagulation should be done preferably between the fifth and the fifteenth day after menstruation, since complications are less likely to occur at this time. This treatment of

73. D'Abreu, A. L., and Lysaght, A. C.: Uraemic Ulcerative Colitis Following Cystoscopy, Brit. J. Urol. **7**:336-344 (Dec.) 1935.

74. Herrold, R. D.; Ewert, E. E., and Maryan, H.: Relation of Chronic Cervicitis to Infection of the Urinary Tract, Surg., Gynec. & Obst. **62**:85-89 (Jan.) 1936.

the cervix should never be performed if acute or subacute inflammatory lesions of the internal or external generative organs are present. Coagulation with short wave diathermy was used, with the indifferent tin plate electrode placed under the patient. The spatula tip positive electrode was used for coagulation of the cervix. The proper dosage with the universal Bovie machine was obtained by setting the indicator on 40 of the coagulation meter scale, which gave the proper milliamperage.

In cases in which the cervix appeared to be edematous and acutely inflamed, with marked lacerations, the infection was best treated first by topical applications of a 10 per cent solution of tannic acid and glycerin into the cervical canal, supplemented by daily douches of hot water. This shrank the cervix materially and reduced the activity of the chronic inflammatory process. The linear "striping" of the cervix was employed as a routine, commencing within the internal os, extending to the external os and continuing this linear striping on the cervical lips at right angles to the linear "striping" of the cervical canal. The edge of the spatula tip electrode was found most suitable. The tip is first placed firmly against the cervical tissue and the coagulation begun.

The condition of patients who had streptococcic infection was improved more than was the condition of those who had bacilluria. The urine of most of these patients was clear on macroscopic examination, and the sediment revealed bacteria but few or no pus cells. The heat-resistant so-called Enterococcus was the most common type of Streptococcus isolated in the examination and study of sediments of the urine. The infected gland-bearing tissue of the cervix was destroyed by deep crucial incisions. It is necessary that coagulation be followed by dilation of the cervical canal, including the internal os.